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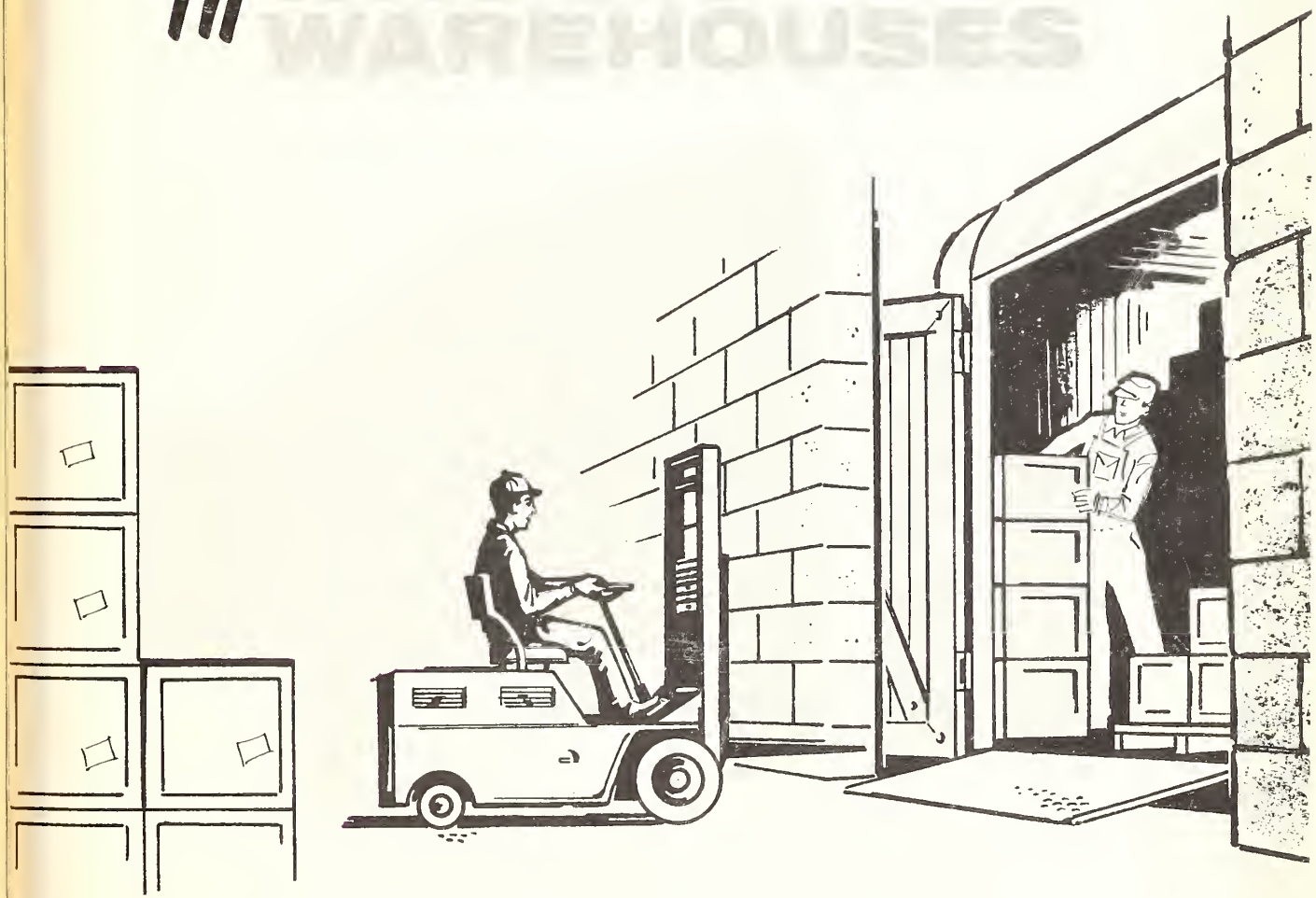
RECEIVING FRUITS and VEGETABLES in WHOLESALE WAREHOUSES



Marketing Research Report No. 478

Transportation and Facilities Research Division
Agricultural Marketing Service
U. S. Department of Agriculture

Preface

The study on which this report is based is part of a research project on handling various types of packages of perishable produce at different stages in the marketing system. This study was conducted under the supervision of Joseph F. Herrick, Jr., marketing research analyst, Handling and Facilities Research Branch, Transportation and Facilities Research Division, Agricultural Marketing Service.

The authors wish to thank the dealers in the farmers' markets and distribution centers who made their facilities available for studies of receiving operations. Credit is due the following: American Stores Co., Baltimore, Md.; Canada Produce Co., Lynchburg, Va.; Columbia State Farmers Market, Columbia, S.C.; Fadler Produce Co., Pittsburg, Kans., and Springfield, Mo.; Houston Produce Terminal, Houston, Tex.; Ben. E. Keith Co., Fort Worth, Tex.; Louisville Produce Terminal, Louisville, Ky.; Pearce, Young-Angel Co., Inc., Columbia, S.C.; A. Reich and Sons, Inc., Kansas City, Mo.; Safeway Stores, Inc., Landover, Md.; Shaeffer-Black Co., Canton, Ohio; Thomas Fruit Co., Inc., Joplin, Mo.

Frederick C. Winter, professor of industrial engineering, Columbia University, formerly consultant to the Transportation and Facilities Research Division, gave many valuable suggestions.

Some of the reports on handling perishable food products, issued by the United States Department of Agriculture, are:

Methods, Equipment, and Facilities for Receiving, Ripening, and Packing Bananas. Marketing Research Report No. 92, June 1955.

Some Improved Methods of Handling Frozen Food in Wholesale Plants. Marketing Research Report No. 107, November 1955.

The Effect of Apple Handling Methods on Storage Space Utilization. Marketing Research Report No. 130, July 1956.

Materials Handling in Public Refrigerated Warehouses. Marketing Research Report No. 145, July 1957.

Comparative Costs of Handling Apples at Packing and Storage Plants. Marketing Research Report No. 215, March 1958.

Apple Sorting Methods and Equipment. Marketing Research Report No. 230, August 1958.

Loading Out Fruits and Vegetables in Wholesale Warehouses. Marketing Research Report No. 282, March 1959.

Mechanically Processing Wholesale Frozen Food Orders. AMS 317, June 1959.

Heat Leakages through Floors, Walls and Ceilings of Apple Storages. Marketing Research Report No. 315, October 1959.

Wholesale Fruit and Vegetable Warehouses; Layouts and Designs. Marketing Research Report No. 467, August 1961.

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Highlights

Receiving by the wholesale distributor of fresh fruits and vegetables includes unloading the product from the carrier, transporting it to the storage area, and placing it in storage where it is available for filling customer orders. Wholesalers use two-wheel handtrucks, two-wheel clamp trucks, semilive skids, dead skids, and pallets to handle the product during the receiving operation.

A wholesaler using two-wheel handtrucks for receiving can reduce combined labor and equipment costs for handling from $1.39 to $0.54 per ton, a reduction of 61 percent, by using a more efficient method.

Many operators used a method in which the transporter waited in the carrier while his handtruck was loaded and also waited in the storage area while the handtruck was unloaded. This procedure resulted in the highest cost operation.

The more productive system used a unit-load method. Stacks of produce were tipped onto the handtruck in the carrier and tipped off in storage. Rehandling in the storage area was eliminated, thus reducing costs to a minimum.

The two-wheel clamp truck was used in a manner similar to the use of the two-wheel handtruck. Labor and equipment costs were as much as $0.88 per ton when hand-stacking was required in storage, and as little as $0.56 per ton when hand-stacking was eliminated by using the unit-load method. The change reduced costs by 36 percent.

Platform equipment such as semilive skids, dead skids, and pallets can carry larger loads than handtrucks. When used with the unit-load method, platform equipment is efficient and productive.

Some wholesalers lose the advantage of the semilive skid and jack system of handling by using hand-stacking in storage. Combined costs of labor and equipment for that method were as much as $0.71 per ton. The unit-load method reduced costs by 34 percent, to $0.47 per ton. To get the full benefit of the unit-load method, packages built into a load on the semilive skid must be left intact when placed in storage. More skids were required for this system than for hand-stacking.

All produce wholesalers who used dead skids and manual or electric-powered low-lift platform trucks also used the unit-load method. When a two-man crew used this equipment, total labor and equipment cost was $0.41 per ton.

Pallets and forklift trucks or high-lift transporters were used with the unit-load method of receiving. This equipment uses vertical storage space more advantageously than any other equipment for the unit-load method. Combined labor and equipment costs were $0.49 per ton for a high-lift transporter when loaded pallets were moved to the pickup position at the threshold of the carrier or onto the receiving platform. When the carrier floor or racks were strong enough, loads were picked up in the carrier, thus reducing costs to $0.46 per ton.

Floor area cost, for each ton stored, varied from $0.19 to $0.39 per ton, depending upon the storage method and type of equipment used. This space cost must be considered in evaluating the costs associated with storage methods and materials-handling equipment.

Hand-stacking in storage makes the most efficient use of floor space. When handtrucks and hand-stacking were used, space cost was $0.19 per ton. When pallets were used and all of them were placed on the floor, the space cost was $0.39 per ton. When 25 percent of all the pallets used were placed on top of pallets already on the floor, the space cost was reduced to $0.31 per ton.

The high labor cost more than offset the low space cost for hand-stacking. Total labor, equipment, and space cost for handtrucks was $1.06 per ton when hand-stacking was used. When pallets were used with partial tiering, the total cost was $0.77 per ton.

The wholesaler can reduce his costs of operation by using the most efficient handling method for his equipment. The floors of many older warehouses are too weak to sustain the loads imposed by newer, more productive materials-handling equipment. As a result, the wholesaler is limited to the less efficient handling units. However, using the most productive operating methods can minimize warehouse operating costs.

RECEIVING FRUITS AND VEGETABLES IN WHOLESALE WAREHOUSES

By Robert K. Bogardus and Richard T. Ferris, *industrial engineers*, Transportation and Facilities Research Division, Agricultural Marketing Service

Background

For the wholesale distributor of fresh fruits and vegetables, handling the product begins when the refrigerated truck or railroad car is moved into position at the warehouse receiving dock. This report deals with the work and equipment required to unload the commodities from the carrier and to move and store them.

Five types of material-handling equipment were observed and studied. These are: two-wheel handtrucks; two-wheel clamp trucks; semi-live skids and jacks; dead skids and low-lift platform trucks; and pallets and forklift trucks. More than one method of operation was used with each type of equipment.

Agricultural Marketing Service industrial engineers studied the use of handling equipment under commercial operating conditions in independently located warehouses operated by wholesale distributors. All of the wholesalers received the same variety of fruits and vegetables.

The warehouse facilities varied. Some were long and narrow; some had limited storage space; in a few, large columns made efficient use of storage areas difficult; several warehouses and market facilities were modern and well planned. Most of the warehouses were single-story structures, with receiving docks at a height for truck beds and for refrigerated railroad car racks. In multistory structures, the principal handling and storage activity was on one floor.

Industrial engineering techniques were used to obtain reliable data on the methods and equipment used. The data were collected in a manner that made it possible to eliminate the effect of unnecessary work and avoidable delays. As a result, the labor and equipment requirements in this report will provide the lowest operating cost possible for the indicated method and crew arrangement. Details on the techniques are in the appendix.

In developing the cost figures, it was assumed that each unit of equipment was fully employed on receiving operations for 2,000 hours each year. As a result, the equipment costs were not inflated by use at less-than-full capacity. In using these figures, equipment costs must be recomputed for hourly usage that is more or less than the 2,000 hours assumed. The most economical equipment for a large volume operation may not be the most economical for small volumes.

It was also assumed that labor rates were $2 per hour for warehousemen and $2.25 per hour for forklift truck operators. These figures include the base hourly rate plus fringe benefits covering the cost of such items as social security, workmen's compensation, paid vacations, and unemployment compensation.

The cost comparisons in this report make no provision for the cost of management and other expenses classified as overhead. To estimate the total costs for receiving operations, add the overhead cost to the costs presented in the comparisons.

The costs of all warehousing operations should be combined and evaluated before any one of the five handling units is selected. The equipment herein limited to receiving activities can also be used for rewarehousing and truck loading.

Costs of the loading-out operations of service wholesalers have already been published.[1] A later report will present an analysis of the combined costs of performing all warehousing operations for different volumes of fruits and vegetables.

The Receiving Operation

In preparation for receiving, the carrier doors were opened, a bridge plate was positioned, and a portable light was installed in the carrier when needed. When loads were braced for shipment, the timbers were removed before unloading began.

The main work of receiving included manually stacking a load on the handling equipment, then transporting and placing the load intact in the storage area. In some methods, the load was removed from the equipment in the storage area and stacked on the floor.

[1] Bogardus, R. K., and Burt, S. W. Loading out Fruits and Vegetables in Wholesale Warehouses. U.S. Dept. Agr. Mktg. Res. Rpt. 282, 53 pp., 1959.

The area was cleaned after the carrier had been unloaded and the commodities had been stored. Lights and bridge plates were removed, doors were closed, platforms swept, and the area put in order for subsequent receiving and handling activities.

Movement of the commodities from the receiving platform to a specific storage location was controlled by several factors, such as the conditions required for maintaining the quality of the produce. Some commodities need low-temperature, high-humidity storage. When this was necessary, the storage area was either the wet or dry cold storage room. When special conditioning was not required, the commodity was placed in the general storage area. Another factor was the volume of the commodity. High-volume items were stored in the warehouse location that would minimize the transportation distance from storage to the order-assembly or truck-loading areas.

In the evaluations that follow, every effort was made to present labor and equipment costs for each equipment type on an equitable basis. Equal transportation distances and uniform package weights were used to accomplish this.

In most cases, incoming carriers can be located at the receiving dock to minimize the transportation distance from carrier to storage. Since the wholesaler usually requires that carriers be located to accomplish this objective, it was assumed that the average distance from receiving dock to storage would be 100 feet. This distance was used in all the labor requirement tables, to establish time spent in transportation.

Fruits and vegetables are packed in a wide variety of package sizes, shapes, types, and weights. Studies of the activities in which these packages were manually lifted and handled revealed that package size, shape, type, and material had no significant effect on time requirements. However, package weight affected the time required to load packages on materials-handling equipment and to stack them in a storage area. For example, a man could load 1 ton of 30-pound packages on two-wheel handtrucks in 4.5 minutes, but 1 ton of 100-pound packages required 2.3 minutes.

Total labor requirements for receiving were calculated for two and more workers, to determine the crew size and the work method that would result in the lowest labor cost per ton for each type of equipment. The computations of labor requirements for each ton received were made on the basis of 40-pound packages, in order to reduce the number of tables for the comparisons based on crew size, method, and type of equipment. Basic data for all package weight categories that were studied can be found in the appendix.

The crew size that resulted in the lowest labor cost per ton for receiving 40-pound packages was the best size for receiving 30-, 50-, and 80-pound packages and also for the majority of methods and equipment types when 100-pound packages were received. In three cases where two-wheel handtrucks were used for handling 100-pound packages, labor requirements could be reduced by adding one or more transporters to the crew.

The handling-equipment load was built in the carrier, whether it was a refrigerated railroad car or a highway truck trailer. In each study, the handling-equipment was loaded or the load was prepared for pickup as close to the "workface" as possible. (The "workface" is the vertical surface of stacked packages that the worker faces while loading handling-equipment.) Keeping close to the workface minimized the time spent in walking while picking up each package, transporting it, and placing it in the load.

In the labor requirement tables, crew sizes were selected and worker assignments were made so that the total man-hour requirements could be kept to a minimum. Different totals reflect the methods of performing the work with the same equipment and different work assignments. For example, for each method and type of equipment, the work of loading the equipment was assigned to one man in one crew arrangement and to two men in another crew arrangement. This was done to determine the optimum crew sizes.

Crews were balanced to minimize idle time. Methods were selected and work assignments recommended to avoid as much work interference as possible. In other words, work was planned so that each assignment could achieve the maximum productivity with the indicated method and type of equipment.

Two–Wheel Handtrucks

Wholesalers in many parts of the United States use two-wheel handtrucks to handle fruits and vegetables (fig. 1). The variety of crew sizes and methods that were observed, when handtrucks were employed, resulted in a wide range of man-hours required for each ton handled.

In one method that was frequently used, the jobs of loading the handtruck, transporting the load, and hand-stacking it in storage were assigned to individual workers. The transporters waited in the carrier while their equipment was loaded and also waited at the storage point while it was unloaded.

A crew of seven men using this method was organized so that three men prepared the carrier for unloading while four waited; then two men loaded the handtrucks, in the carrier, three transported the loads to storage, and two worked in the storage area removing packages from the handling equipment and stacking them on the floor (fig. 2). When the carrier was completely unloaded, three men cleaned up the working areas.

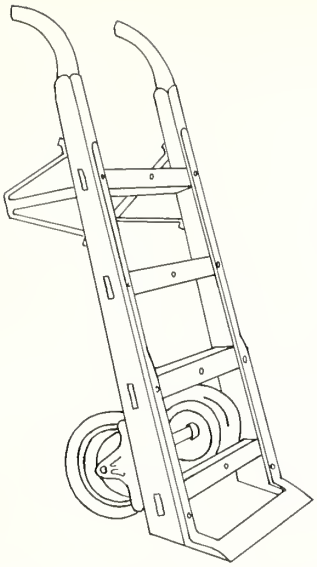

FIGURE 1.—Two-wheel handtruck.

FIGURE 2.—Transporting a load to storage.

The labor required to receive and store 1 ton of produce was 0.633 man-hour when the seven-man crew used this method (table 1).

A four-man crew using the same method, but with one loader, two transporters, and one stacker, required 0.691 man-hour to receive 1 ton (table 1). Each handtruck carried six 40-pound packages, a total of 240 pounds per trip.

TABLE 1.—*Labor required to receive 1 ton of produce in 40-pound packages with 2-wheel handtrucks and specified crew organizations when transporters wait for handtruck loading and unloading* [1]

Time item	7-man crew [2]		4-man crew [3]	
	Workers	Labor required	Workers	Labor required
Productive labor:	*Number*	*Man-hours*	*Number*	*Man-hours*
Set up and clean up	3	0. 006	3	0. 006
Enter carrier	3	. 007	2	. 007
Set down empty handtruck	3	. 004	2	. 004
Load handtruck	2	. 086	1	. 069
Pick up loaded handtruck	3	. 006	2	. 006
Leave carrier	3	. 018	2	. 018
Transport [4]	3	. 122	2	. 122
Set down loaded handtruck	3	. 006	2	. 006
Handstack in storage	2	. 113	1	. 106
Pick up empty handtruck	3	. 003	2	. 003
Total productive labor		. 371		. 347
Unproductive labor:				
Balance of crew waits while 3 men set up and clean up	4	. 008	1	. 002
Transporters wait for handtruck loading	3	. 043	2	. 069
Transporters wait for handtruck unloading	3	. 056	2	. 106
Loaders wait for transporters	2	. 091	1	. 102
Stackers wait for transporters	2	. 064	1	. 065
Total unproductive labor		. 262		. 344
Total labor	7	. 633	4	. 691
Elapsed hours		. 0904		. 1727

[1] Six 40-pound packages loaded on each handtruck = 0.12 on.

[2] Crew organization: 3 men set up and clean up while wait; 2 men load handtrucks in carrier, 3 transport loads o storage, and 2 hand-stack in storage.

[3] Crew organization: 3 men set up and clean up while 1 waits; 1 man loads handtrucks in carrier, 2 transport loads to storage, and 1 hand-stacks in storage.

[4] Transport loads to storage and return to carrier with empty handtruck; 1-way distance is 100 feet.

FIGURE 3.—Hand-stacking packages at the storage point.

A more productive method for using two-wheel handtrucks differed from the one just described only in the assignment of work to the transporters. Transporters exchanged a loaded handtruck for an empty one at the storage location and an empty one for a loaded one in the carrier. Additional handtrucks were required. Two handtrucks for each transporter were adequate. An eight-man crew using this method was assigned as follows: Three men set up and cleaned up while five men waited; two men loaded handtrucks, four transported the loads, and two hand-stacked in storage (fig. 3). Labor requirements for this method were 0.468 man hour per ton (table 2). Since each handtruck carried 0.12 ton per trip, 8.3 trips were made for each ton.

A second crew arrangement using this method employed four men. Three men set up and cleaned up while one waited; then one man loaded handtrucks (fig. 4), two transported loads, and one hand-stacked the commodity in the storage area. The labor required for this crew totaled 0.432 man-hour (table 2), a 32-percent reduction below

FIGURE 4.—Loading a handtruck.

TABLE 2.—*Labor required to receive 1 ton of produce in 40-pound packages with 2-wheel handtrucks and specified crew organizations when transporters exchange empty and loaded handtrucks* [1]

Time item	8-man crew [2]		4-man crew [3]	
	Workers	Labor required	Workers	Labor required
	Number	*Man-hours*	*Number*	*Man-hours*
Productive labor:				
Set up and clean up	3	0. 006	3	0. 006
Load handtruck	2	. 086	1	. 069
Enter carrier	4	. 007	2	. 007
Exchange empty for loaded handtruck	4	. 011	2	. 011
Leave carrier	4	. 018	2	. 018
Transport [4]	4	. 122	2	. 122
Exchange loaded for empty handtruck	4	. 026	2	. 027
Hand-stack in storage	2	. 113	1	. 106
Total productive labor		. 389		. 365
Unproductive labor:				
Balance of crew waits while 3 men set up and clean up	5	010	1	. 002
Loader waits for stacker	2	. 027	1	. 037
Transporter waits for stacker	4	. 042	2	. 028
Total unproductive labor		. 079		. 067
Total labor	8	. 468	4	. 432
Elapsed hours		. 0585		. 1080

[1] Six 40-pound packages loaded on each handtruck = 0.12 ton.

[2] Crew organization: 3 men set up and clean up while 5 wait; 2 men load handtrucks in carrier, 4 transport loads to storage, and 2 hand-stack in storage.

[3] Crew organization: 3 men set up and clean up while 1 waits; 1 man loads handtrucks in carrier, 2 transport loads to storage, and 1 hand-stacks in storage.

[4] Transport loads to storage and return to carrier with empty handtruck; 1-way distance is 100 feet.

FIGURE 5.—Tipping a load onto a handtruck.

FIGURE 6.—Transporter positioning a load to be tipped off.

that required when a seven-man crew used the first method described (table 1).

The four-man crew would require 0.378 man-hour per ton for receiving produce in 100-pound packages; adding one transporter would reduce the total labor requirement to 0.318 man-hour per ton. The four-man crew would not have to be adjusted for other package weights.

In the first two methods, hand-stacking was limited to a height that the workers could reach without climbing on the stack. Since dimensions of the packages vary, the final stacking height also varied. When commodities are stacked very high, the workers must climb up on previously stacked packages. This causes product damage and increases labor requirements. Often, a worker stands on the stack while a second worker lifts packages to him. This double handling is costly and produces shrinkage from unavoidable damage.

A third method of operating handtrucks resulted in a further reduction of the labor requirements for each ton received. The basic change was the elimination of hand-stacking by tipping off the handtruck load in the storage area. The use of the unit-load eliminated the second handling.

For this method, the packages must be stacked on the bed of the carrier, or pulled into an open area with a hook, so the stack can be tipped. The transporter tips the stack away from the handtruck, then slides the shoe of the handtruck under the load. The load is then tipped back against the handtruck and carried away (fig. 5). The transporter takes the load to the storage area and stops far enough away from the wall or stored items so that the load can be tipped away from the handtruck and the shoe slipped from under the load (fig. 6). The load is then pushed against the wall or other stacks.

A crew of 6 men using this method would be assigned as follows: 3 men would set up and clean up while 3 wait; then 2 men would position packages for pickup in the carrier and 4 transporters would tip the loads onto their handtrucks in the carrier and then tip them off in storage. The labor required for this crew size and arrangement would be 0.273 man-hour per ton (table 3).

When vegetables are received in 100-pound packages, the total labor requirement for this crew size would be 0.273 man-hour per ton. Adding 5 transporters to the crew would reduce the total to 0.147 man-hour per ton for this weight package. No change in crew size would be necessary for any other package weights handled.

A three-man crew that used one man to build loads and two men to transport would perform the same work and require 0.267 man-hour to move a ton of produce (table 3). This is a reduction of 58 percent from the man-hours required by the seven-man crew using the first method (table 1).

The three-man crew just described would have to be supplemented by two transporters to minimize man-hour requirements when 100-pound packages are received. For that package weight, the man-hour requirement with the three-man crew would be 0.267 per ton. With the two additional transporters, the total would drop to 0.228 man-hour per ton. For other package weights, minimum labor requirements would be achieved with the three-man crew.

One-hundred-pound sacks of potatoes can be built into loads on a two-wheel handtruck so that they can also be tipped off in storage as illustrated in figure 7. Two sacks are set on end on the handtruck, then three sacks are set on these horizontally. In tipping them off, the handtruck is stopped approximately 6 inches from the wall or from sacks already in place. The load is thrust forward and tipped off, and the handtruck is removed. The load is canted toward the wall to maintain stability.

The combined labor and equipment costs for two-wheel handtrucks using the methods that have been described ranged from a high of $1.39

TABLE 3.—*Labor required to receive 1 ton of produce in 40-pound packages with 2-wheel handtrucks and specified crew organizations when transporters tip loads on and off handtrucks* [1]

Time item	6-man crew [2]		3-man crew [3]	
	Workers	Labor required	Workers	Labor required
	Number	*Man-hours*	*Number*	*Man-hours*
Productive labor:				
Set up and clean up	3	.006	3	0.006
Build loads	2	.086	1	.069
Enter carrier	4	.007	2	.007
Tip on load	4	.012	2	.012
Leave carrier	4	.018	2	.018
Transport [4]	4	.122	2	.122
Tip off load	4	.015	2	.015
Total productive labor		.266		.249
Unproductive labor:				
Balance of crew waits while 3 men set up and clean up	3	.006		
Loaders wait for transporters	2	.001	1	.018
Total unproductive labor		.007		.018
Total labor	6	.273	3	.267
Elapsed hours		.0455		.0890

[1] Six 40-pound packages loaded on each handtruck = 0.12 ton.

[2] Crew organization: 3 men set up and clean up while 3 wait; 2 men build loads in carrier, and 4 transport loads and tip them off in storage.

[3] Crew organization: 3 men set up and clean up; 1 man builds loads in carrier, and 2 transport loads to and tip them off in storage.

[4] Transport loads to storage and return to carrier with empty handtruck; one-way distance is 100 feet.

per ton (table 4) to a low of $0.54. The highest costs were incurred when the poorest operating method was employed. When transporters waited for their handtrucks to be loaded and unloaded, costs were $1.39 per ton for a four-man crew and $1.28 for a seven-man crew. Adding extra handtrucks eliminated the need for transporters to wait in the carrier and at the stacking point. As a result, costs were $0.95 per ton for an eight-man crew and $0.87 per ton for a four-man crew. The lowest cost system was the one in which the commodities were tipped off rather than hand-stacked in storage. When handtruck loads were tipped off in storage, the cost was $0.56 per ton for a six-man crew and $0.54 a ton for a three-man crew.

Wholesalers most frequently use the method that incurs the highest operating cost per ton. These costs can be reduced by changing to one of the two lower cost systems. The tipoff method requires more floor space than the hand-stacking method.

FIGURE 7.—Sacks of potatoes tipped off in storage.

Two-Wheel Clamp Trucks

The two-wheel clamp truck is similar to the two-wheel handtruck (fig. 8). However, with the clamp truck, the load is picked up by opening the clamps, pushing the truck against the load, and then compressing and locking the clamps around the load. The load is then tilted against the handtruck and transported to the storage area. The transporter positions the truck at the storage point, releases the clamps and withdraws the handtruck. The released load is left in the storage area in position for hand-stacking.

The clamp truck was originally designed for

TABLE 4.—*Labor and equipment costs for receiving 1 ton of produce in 40-pound packages when 2-wheel handtrucks and various methods and crew sizes were used*

Method	Crew size	Crew assignments			Elapsed time	Labor required	Labor and equipment costs		
		Loading	Transporting	Stacking			Labor [1]	Equipment [2]	Total
	Number	*Number*	*Number*	*Number*	*Hours*	*Man-hours*	*Dollars*	*Dollars*	*Dollars*
Transporters wait while loaders load empty handtrucks, then transport loads 100 feet to storage area where they wait while stackers unload handtrucks	4	1	2	1	0. 1727	0. 691	1. 38	0. 01	1. 39
	7	2	3	2	. 0904	. 633	1. 27	. 01	1. 28
Transporters exchange empty for loaded handtrucks at loading point, transport loads 100 feet to storage area, and exchange loaded for empty handtrucks	8	2	4	2	. 0585	. 468	. 94	. 01	. 95
	4	1	2	1	. 1080	. 432	. 86	. 01	. 87
Transporters exchange empty for loaded handtrucks at loading point, transport loads 100 feet to storage area, and tip loads off handtrucks intact	6	2	4	0	. 0455	. 273	. 55	. 01	. 56
	3	1	2	0	. 0890	. 267	. 53	. 01	. 54

[1] Labor costs are based on $2.00 per hour for all workers.

[2] Equipment costs are the product of machine-hours times the cost per hour of use for each equipment type as given in appendix table 40. These costs are based on the following requirements:

Crew size	Elapsed time	2-wheel handtruck		Bridge plates		Equipment cost
Number	*Hours*	*Number*	*Machine-hours*	*Number*	*Machine-hours*	*Dollars*
4	0. 1727	2	0. 345	1	0. 173	0. 0045 raised to $0. 01
7	. 0904	3	. 271	1	. 090	. 0026 raised to . 01
8	. 0585	8	. 468	1	. 058	. 0024 raised to . 01
4	. 1080	4	. 432	1	. 108	. 0034 raised to . 01
6	. 0455	4	. 182	1	. 046	. 0014 raised to . 01
3	. 0890	2	. 178	1	. 089	. 0023 raised to . 01

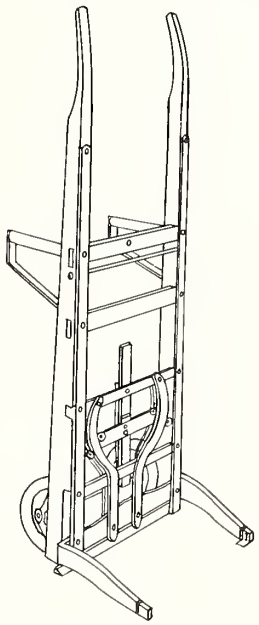

FIGURE 8.—Two-wheel clamp truck.

use with wood containers. With the change to fiberboard containers, the clamps have been adapted with wide flanges to slide under and lift the carton instead of digging into it for a grip.

Labor requirements were similar for both a seven-man and a four-man crew when two-wheel clamp trucks were used to pick up, transport, and release loads for hand-stacking. For the seven-man crew, three men set up and cleaned up while four waited; then two men built the loads for clamp truck pickup, three transported the loads 100 feet to storage (fig. 9) and two hand-stacked the packages in the designated storage area. The total requirement for this crew was 0.434 man-hour per ton (table 5).

When the four-man crew was used, three men set up while one waited, then one man built loads in the carrier, two picked up and transported the loads 100 feet and released them in the storage area, and one hand-stacked them in storage (fig. 10). On completion of the work, three men cleaned up. This crew size required 0.432 man-hour for each ton received (table 5).

The main difference between the two crews is in the elapsed time required to unload each ton.

FIGURE 9.—Transporting a clamp truck load of produce.

The seven-man crew required 0.062 hour; the four-man crew, 0.108 hour.

A second method required less labor because hand-stacking was eliminated. As a result, when a six-man crew was used, three men set up while three waited, then two men built loads in the carrier and four picked up the loads, transported them to storage, and released them in final position in the storage area, then three men cleaned up. The total labor for the six-man crew using

FIGURE 10.—Hand-stacking packages in cold storage.

TABLE 5.—*Labor required to receive 1 ton of produce in 40-pound packages with 2-wheel clamp trucks and specified crew organizations when packages were hand-stacked in storage* [1]

Time item	7-man crew [2]		4-man crew [3]	
	Workers	Labor required	Workers	Labor required
	Number	*Man-hours*	*Number*	*Man-hours*
Productive labor:				
Set up and clean up	3	0.006	3	0.006
Build loads	2	.086	1	.069
Enter carrier	3	.008	2	.008
Pick up load	3	.021	2	.021
Leave carrier	3	.018	2	.018
Transport [4]	3	.122	2	.122
Release load	3	.011	2	.011
Hand-stack in storage	2	.113	1	.106
Total productive labor		.385		.361
Unproductive labor:				
Balance of crew waits while 3 men set up and clean up	4	.008	1	.002
Loaders wait for transporters	2	.034		
Stackers wait for transporters	2	.007		
Loaders wait for stacker			1	.037
Transporters wait for stacker			2	.032
Total unproductive labor		.049		.071
Total labor	7	.434	4	.432
Elapsed hours		.0620		.1080

[1] Six 40-pound packages loaded on each clamp truck = 0.12 ton.

[2] Crew organization: 3 men set up and clean up while 4 wait; 2 men build loads in carrier, 3 transport loads to storage, and 2 hand-stack in storage.

[3] Crew organization: 3 men set up and clean up while 1 waits; 1 man builds loads in carrier, 2 transport loads to storage, and 1 hand-stacks in storage.

[4] Transport loads to storage and return to carrier with empty clamp truck; one-way distance is 100 feet.

TABLE 6.—*Labor required to receive 1 ton of produce in 40-pound packages with 2-wheel clamp trucks and specified crew organizations when loads were released intact in storage* [1]

Time item	6-man crew [2]		3-man crew [3]	
	Workers	Labor required	Workers	Labor required
	Number	*Man-hours*	*Number*	*Man-hours*
Productive labor:				
Set up and clean up	3	0.006	3	0.006
Build loads	2	.086	1	.069
Enter carrier	4	.008	2	.008
Pick up load	4	.021	2	.021
Leave carrier	4	.018	2	.018
Transport [4]	4	.122	2	.122
Release load	4	.011	2	.011
Total productive labor		.272		.255
Unproductive labor:				
Balance of crew waits while 3 men set up and clean up	3	.006		
Loaders wait for transporters	2	.004	1	.021
Total unproductive labor		.010		.021
Total labor	6	.282	3	.276
Elapsed hours		.0470		.0920

[1] Six 40-pound packages loaded on each clamp truck = 0.12 ton.

[2] Crew organization: 3 men set up and clean up while 3 wait; 2 men build loads in carrier, and 4 transport loads to storage.

[3] Crew organization: 3 men set up and clean up; 1 builds loads in carrier, and 2 transport loads to storage.

[4] Transport loads to storage and return to carrier with empty clamp truck; 1-way distance is 100 feet.

TABLE 7.—*Labor and equipment costs for receiving 1 ton of produce in 40-pound packages when 2-wheel clamp trucks and various methods and crew sizes were used*

Method	Crew size	Crew assignments			Elapsed time	Labor required	Labor and equipment costs		
		Loading	Transporting	Stacking			Labor [1]	Equipment [2]	Total
	Number	*Number*	*Number*	*Number*	*Hours*	*Man-hours*	*Dollars*	*Dollars*	*Dollars*
Loaders build loads in carrier, transporters move load 100 feet to storage area with clamp trucks and release, and stackers hand-stack in storage	7	2	3	2	0.0620	0.434	0.87	0.01	0.88
	4	1	2	1	.1080	.432	.86	.01	.87
Loaders build loads in carrier and transporters move loads 100 feet to storage area with clamp trucks and deposit loads intact in storage	6	2	4	0	.0470	.282	.56	.01	.57
	3	1	2	0	.0920	.276	.55	.01	.56

[1] Labor costs are based on $2.00 per hour for all workers.

[2] Equipment costs are the product of machine-hours times the cost per hour of use for each equipment type as given in appendix table 40. These costs are based on the following requirements:

Crew size	Elapsed time	2-wheel clamp trucks		Bridge plates		Combined cost
Number	*Hours*	*Number*	*Machine-hours*	*Number*	*Machine-hours*	*Dollars*
7	0.0620	3	0.186	1	0.062	0.0025 raised to $0.01
4	.1080	2	.216	1	.108	.0037 raised to .01
6	.0470	4	.188	1	.047	.0022 raised to .01
3	.0920	2	.184	1	.092	.0031 raised to .01

this method was 0.282 man-hour per ton (table 6).

A three-man crew using this method required 0.276 man-hour to unload 1 ton of produce from a carrier and place it in storage (table 6). Three men set up before unloading began and cleaned up when it was completed; one man built loads in the carrier and two transported the loads 100 feet to storage and released them in the stack.

Table 7 shows combined costs of labor and equipment per ton of produce received when two-wheel clamp trucks were used. The seven-man and four-man crews using the method that included hand-stacking in storage incurred total costs of $0.88 and $0.87 per ton, respectively. Costs totaled $0.57 and $0.56 per ton, respectively, for the six-man and three-man crews that used unit loads stored intact instead of using hand-stacking. Eliminating hand-stacking resulted in a cost reduction of 36 percent.

The wholesaler who sells a general line of fruits and vegetables needs the two-wheel handtruck to supplement his two-wheel clamp trucks. The handtruck is used for bagged items such as onions and potatoes. The method employing hand-stacking or unit-loads can be used with both clamp trucks and handtrucks.

Platform Type Equipment

Semilive skids, dead skids, and pallets provide a platform on which a large quantity of produce can be transported to the storage area. The load stacked on the platform type equipment is usually placed in storage as a unit. Handling is reduced when unit-loads are used. The load can be handled intact from the carrier to storage, then to the order-assembly area or the delivery truck. Fewer handlings of produce lower the labor cost and reduce damage to the product.

In comparing the 2 types of skids and pallets, dimensions were selected to meet 2 criteria: (1) the size selected had been in commercial use in the wholesale fruit and vegetable industry, and (2) the surface area was approximately the same for skids and pallets. Semilive and dead skids were 36 by 54 inches; pallets were 48 by 40 inches.

Semilive Skids and Jacks

Many wholesalers have the produce hand-stacked in storage, even though they use semilive skids and jacks for handling operations (fig. 11). A few wholesalers use unit-loads in both receiving and loading-out operations.

A five-man crew using semilive skids and jacks required 0.350 man-hour for each ton received (table 8). Forty 40-pound cartons were loaded on each skid. With each round trip, 0.8 ton was moved. The crew was organized so that three

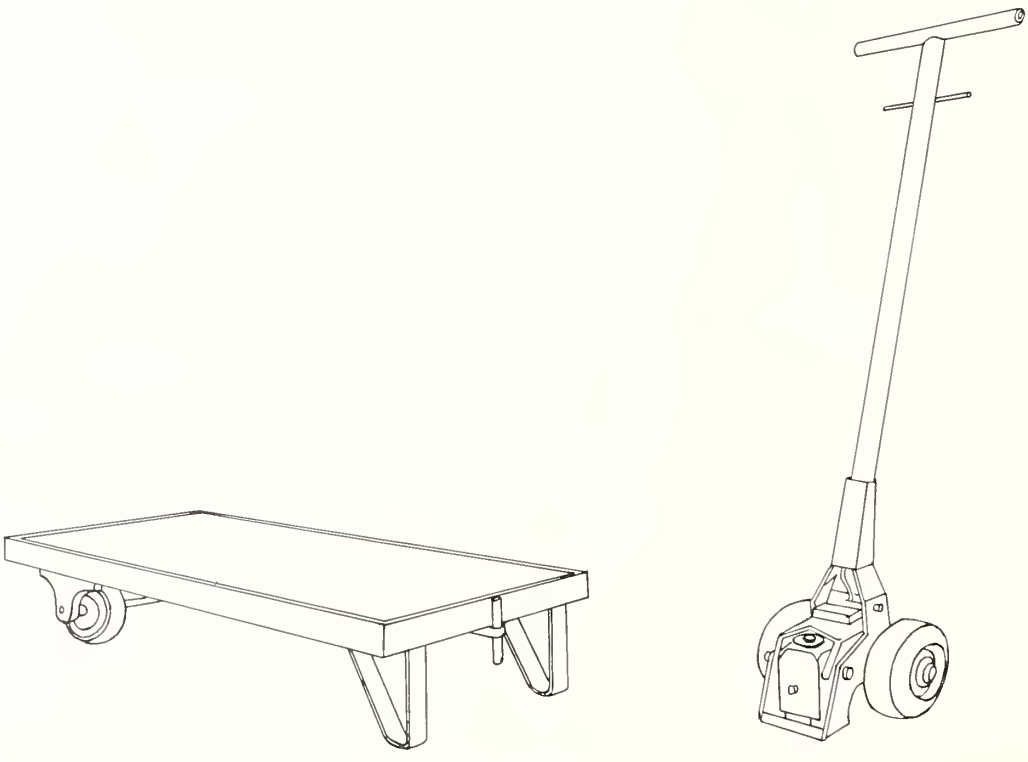

FIGURE 11.—Semilive skid and jack.

TABLE 8.—*Labor required to receive 1 ton of produce in 40-pound packages with semilive skids and jacks and specified crew organizations when commodities were hand-stacked in storage* [1]

Time item	5-man crew [2]		3-man crew [3]	
	Workers	Labor required	Workers	Labor required
	Number	*Man-hours*	*Number*	*Man-hours*
Productive labor:				
Set up and clean up	3	0.006	3	0.006
Position skid for loading	1	.007	1	.007
Load skid	2	.121	1	.083
Set down empty skid	1	.005	1	.005
Enter carrier	1	.004	1	.004
Pick up load	2	.005	2	.005
Leave carrier	2	.010	2	.010
Transport [4]	1	.023	1	.023
Set down load	1	.006	1	.006
Pick up empty skid	1	.003	1	.003
Hand-stack in storage	2	.113	1	.106
Total productive labor		.303		.258
Unproductive labor:				
Balance of crew waits while 3 men set up and clean up	2	.004		
Transporter waits for loaders	1	.020		
Stackers wait for loaders	2	.023		
Transporter waits for stacker			1	.058
Loader waits for stacker			1	.008
Total unproductive labor		.047		.066
Total labor	5	.350	3	.324
Elapsed hours		.0700		.1080

[1] Forty 40-pound packages loaded on each 36- by 54-inch skid = 0.80 ton.

[2] Crew organization: 3 men set up and clean up while 2 wait; 2 men load skids in carrier (1 loader positions empty skid while other loader helps transporter move load out of carrier), 1 transports loads to storage, and 2 hand-stack in storage.

[3] Crew organization: 3 men set up and clean up; 1 man positions and loads skids in carrier, then helps transporter move loads out of carrier, 1 transports loads to storage, and 1 hand-stacks in storage.

[4] Transport loaded skid to storage and return to carrier with empty skid; one-way distance is 100 feet.

men set up for receiving while two waited; then two men positioned and loaded skids, one transported the loads 100 feet to storage, and two hand-stacked the packages in storage; and three men cleaned up when the job was finished. One loader positioned skids for loading while the other helped the transporter move the loaded skid out of the carrier.

A three-man crew using the same method was organized with three men to set up and clean up; one man to position and load skids, one to transport the loads 100 feet to storage, and one to hand-stack the produce in storage. The loader helped the transporter move the loaded skid out of the carrier. Labor requirements for this crew were 0.324 man-hour per ton (table 8).

Crew sizes and labor requirements were reduced when unit-loads, instead of hand-stacking, were used for storage. A three-man crew, with two men loading skids and one transporting loads (figs. 12 and 13), could move 1 ton of produce in 0.070 hour with a total labor requirement of 0.210 man-hour (table 9). One loader positioned a skid for loading while the other loader helped the transporter move the loaded skid out of the carrier.

FIGURE 12.—Two men loading a skid.

The transporter pulled the load to the storage area, positioned it, and set it down intact. He then returned to the carrier with his jack to pick up another load.

FIGURE 13.—Preparing to pick up a semilive skid.

A two-man crew using unit-loads can receive 1 ton of produce with a labor requirement of 0.202 man-hour (table 9). Two men set up and clean up; then 1 man loads skids and helps the transporter move them out of the carrier, and 1 man transports the loads and releases them in the storage area intact. The transporter returns to the carrier with his jack to pick up additional loads. The transporter is also responsible for having a supply of empty skids near the carrier.

Combined costs for labor and equipment (table 10) were $0.71 per ton for the five-man crew, and $0.66 per ton for the three-man crew when hand-stacking in storage was part of the receiving operation. When the unit-load method was used for receiving, total costs were $0.49 per ton for the three-man crew and $0.47 per ton for the two-man crew. Using the best crew arrangement for each of the two methods reduced labor requirements to 38 percent less for the unit-load method than for hand-stacking; total costs were 29 percent less.

When semilive skids are not in use, they can be stacked (fig. 14) or set on end to reduce storage space.

Dead Skids

Forty 40-pound cartons are loaded on each 36- by 54-inch dead skid. Thus, 0.8 ton can be moved on each trip from carrier to storage area. All wholesalers studied who owned this equipment used the unit-load method of handling. The low-lift platform trucks observed were either manually operated or electrically powered (figs. 15 and 16). The most productive crew arrangements for both types of equipment required the same total labor per ton.

A three-man crew using either powered or manual equipment would be assigned so that three men set up for receiving and three cleaned up when the work was completed (figs. 17 and 18). During

TABLE 9.—*Labor required to receive 1 ton of produce in 40-pound packages with semilive skids and jacks and specified crew organizations when loads were deposited intact in storage* [1]

Time item	3-man crew [2]		2-man crew [3]	
	Workers	Labor required	Workers	Labor required
Productive labor:	*Number*	*Man-hours*	*Number*	*Man-hours*
Set up and clean up	3	0. 006	2	0. 007
Position skid for loading	1	. 007	1	. 007
Load skid	2	. 121	1	. 083
Enter carrier	1	. 004	1	. 004
Pick up load	2	. 005	2	. 005
Leave carrier	2	. 010	2	. 010
Transport [4]	1	. 023	1	. 023
Set down load	1	. 006	1	. 006
Total productive labor		. 182		. 145
Unproductive labor:				
Transporter waits for loaders	1	. 028	1	. 057
Total unproductive labor		. 028		. 057
Total labor	3	. 210	2	. 202
Elapsed hours		. 0700		. 1010

[1] Forty 40-pound packages loaded on each 36- by 54-inch skid=0.80 ton.

[2] Crew organization: 3 men set up and clean up; 2 men load skids in carrier (1 loader positions empty skids while other loader helps transporter move load out of carrier), and 1 transports loads and deposits them in storage.

[3] Crew organization: 2 men set up and clean up; 1 man positions and loads skids in carrier, then helps transporter move load out of carrier, and 1 transports loads and deposits them in storage.

[4] Transport loaded skid to storage and return to carrier with empty skid; one-way distance is 100 feet.

TABLE 10.—*Labor and equipment costs for receiving 1 ton of produce in 40-pound packages when semilive skids and jacks and various methods and crew sizes were used*

Method	Crew size	Crew assignments			Elapsed time	Labor required	Labor and equipment costs		
		Loading	Transporting	Stacking			Labor [1]	Equipment [2]	Total
	Number	*Number*	*Number*	*Number*	*Hours*	*Man-hours*	*Dollars*	*Dollars*	*Dollars*
1 worker positions skid, loaders load skids in carrier, transporter moves load 100 feet to storage area, and stackers hand-stack commodities in storage	5	2	1	2	0. 0700	0. 350	0. 70	0. 01	0. 71
	3	1	1	1	. 1080	. 324	. 65	. 01	. 66
1 worker positions skid, loaders load skids in carrier, 2 workers pick up skid and move it out of carrier, transporter moves load 100 feet to storage area and sets it down in storage intact	3	2	1	0	. 0700	. 210	. 42	. 07	. 49
	2	1	1	0	. 1010	. 202	. 40	. 07	. 47

[1] Labor costs are based on $2.00 per hour for all workers.

[2] Equipment costs are the product of machine-hours times the cost per hour of use for each equipment type as given in appendix tables 40 and 41. These costs are based on the following requirements:

Crew size	Elapsed time	Skid jacks		Semilive skids		Bridge plates		Combined cost
Number	*Hours*	*Number*	*Machine-hours*	*Number*	*Machine-hours*	*Number*	*Machine-hours*	*Dollars*
5	0. 0700	1	0. 070	3	0. 210	1	0. 070	0. 0027 raised to $0. 01
3	. 1080	1	. 108	3	. 324	1	. 108	. 0041 raised to . 01
3	. 0700	1	. 070	1. 25	----------	1	. 070	
2	. 1010	1	. 101	1. 25	----------	1	. 101	

FIGURE 14.—Empty skids stacked in storage.

unloading, two men would position and load skids while 1 transported the loads, set them intact in the storage area (fig. 19), and then returned to the carrier. Labor requirements total 0.205 man-hour for either manual or powered low-lift platform trucks (table 11). The total productive labor for powered equipment was less, but the unproductive labor or waiting time for the transporter increased.

A crew of two men using either type of equipment required 0.197 man-hour per ton (table 11). For this crew size, two men set up for unloading, then one man positioned and loaded skids and one transported the skids, set them in storage, and returned to the carrier (fig. 20). When the skids were not in use, they were stacked to reduce the floor area required for their storage. The two-man crew required less labor per ton than the three-man crew, because one man was more productive in loading skids than two men were. With two men, small intermittent delays accumulated to a total of 0.038 man-hour per ton.

Costs per ton were slightly lower for manually operated platform trucks because of the lower initial investment. For the three-man crew, the cost was $0.43 per ton with manual equipment (table 12), and $0.44 per ton with powered equipment. When a two-man crew was used, the costs were $0.41 per ton with manual equipment and $0.43 per ton for powered equipment.

Costs are less for the two-man crew than for the three-man crew when dead skids are used, regardless of whether the equipment is manually or electrically powered. Before choosing manual or powered equipment for this work, however, management should consider the costs of related operations such as assembly and truck loading.

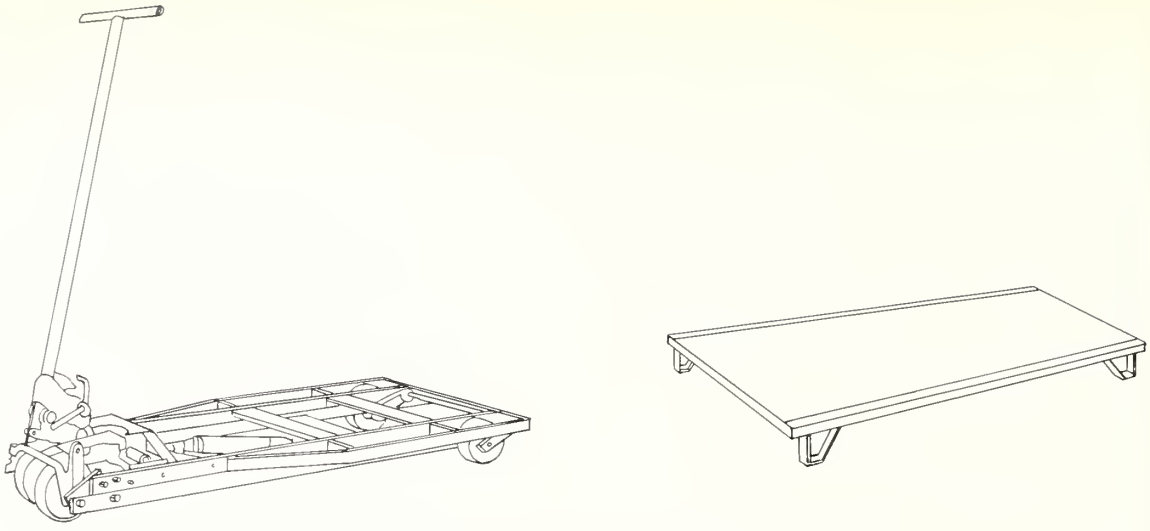

FIGURE 15.—Manual low-lift platform truck and dead skid.

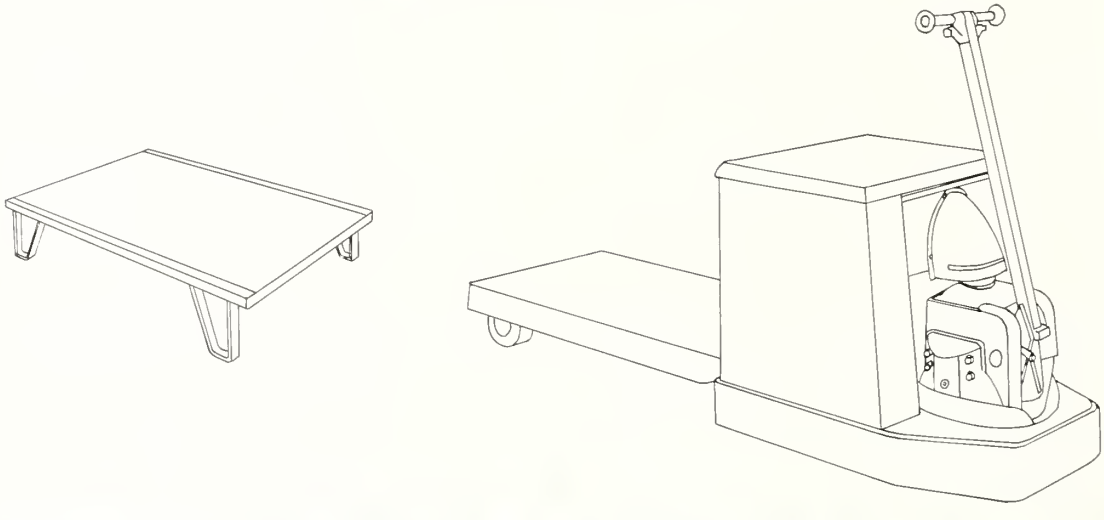

FIGURE 16.—Dead skid and electric low-lift platform truck.

FIGURE 17.—Using an electric platform truck to remove a skid from a refrigerated railroad car. Bridge plate spans the gap between the carrier and the platform.

FIGURE 18.—Transporting a skid load with a manual platform truck.

TABLE 11.—*Labor required to receive 1 ton of produce in 40-pound packages with dead skids and specified equipment and crew organizations* [1]

Time item	Mechanical low-lift platform trucks				Electric low-lift platform trucks			
	3-man crew [2]		2-man crew [3]		3-man crew [2]		2-man crew [3]	
	Workers	Labor required	Workers	Labor required	Workers	Labor required	Workers	Labor required
Productive labor:	*Number*	*Man-hours*	*Number*	*Man-hours*	*Number*	*Man-hours*	*Number*	*Man-hours*
Set up and clean up	3	0. 006	2	0. 007	3	0. 006	2	0. 007
Position skid for loading	2	. 012	1	. 012	2	. 012	1	. 012
Load skid	2	. 121	1	. 083	2	. 121	1	. 083
Enter carrier	1	. 004	1	. 004	1	. 003	1	. 003
Pick up loaded skid	1	. 003	1	. 003	1	. 004	1	. 004
Leave carrier	1	. 004	1	. 004	1	. 003	1	. 003
Transport [4]	1	. 027	1	. 027	1	. 019	1	. 019
Position loaded skid for set-down	1	. 011	1	. 011	1	. 005	1	. 005
Set down loaded skid	1	. 002	1	. 002	1	. 002	1	. 002
Total productive labor		. 190		. 153		. 175		. 138
Unproductive labor:								
Transporter waits for loader	1	. 015	1	. 044	1	. 030	1	. 059
Total unproductive labor		. 015		. 044		. 030		. 059
Total labor	3	. 205	2	. 197	3	. 205	2	. 197
Elapsed hours		. 0683		. 0985		. 0683		. 0985

[1] Forty 40-pound packages loaded on each 36- by 54-inch skid=0.80 ton.

[2] Crew organization: 3 men set up and clean up; 2 men position and load skids in carrier, and 1 transports loads to storage.

[3] Crew organization: 2 men set up and clean up; 1 man positions and loads skids in carrier, and 1 transports loads to storage.

[4] Transport loaded skid to storage and return to carrier with empty skid; one-way distance is 100 feet.

FIGURE 19.—Positioning a skid load of potatoes in storage.

FIGURE 20.—Well-organized storage area with potatoes on dead skids.

Pallets

All wholesalers studied who used pallets and pallet-handling equipment also used the unit-load method. In addition to handling unit-loads, forklift trucks or high-lift transporters can be used not only to pick up, transport, and place the pallet load in storage but also to elevate the load. Therefore, vertical storage space can be used in the warehouse. With other types of equipment, the vertical space can be used only when the packages are hand-stacked. Even then, the height to which loads can be built is limited.

The number of pallets that can be tiered has

TABLE 12.—*Labor and equipment costs for receiving 1 ton of produce in 40-pound packages when dead skids and low-lift platform trucks and various methods and crew sizes were used*

Type of truck and method	Crew size	Crew assignments		Elapsed time	Labor required	Labor and equipment costs		
		Loaders	Transporters			Labor [1]	Equipment [2]	Total
Electric truck:	*Number*	*Number*	*Number*	*Hours*	*Man hours*	*Dollars*	*Dollars*	*Dollars*
Loaders position and load skids in carrier, and transporter moves loaded skid 100 feet to storage area and deposits load in storage intact	3	2	1	0. 0683	0. 205	0. 41	0. 03	0. 44
	2	1	1	. 0985	. 197	. 39	. 04	. 43
Mechanical truck:								
Loaders position and load skids in carrier, and transporter moves loaded skid 100 feet to storage area and deposits load in storage intact	3	2	1	. 0683	. 205	. 41	. 02	. 43
	2	1	1	. 0985	. 197	. 39	. 02	. 41

[1] Labor costs are based on $2 per hour for all workers.

[2] Equipment costs are the product of machine-hours times the cost per hour of use for each equipment type as given in appendix tables 40 and 41. These costs are based on the following requirements:

Crew size	Platform trucks			Dead skids	Bridge plates		Combined cost
Number	*Type*	*Number*	*Machine-hours*	*Number*	*Number*	*Machine-hours*	*Dollars*
3	Electric	1	0. 0683	1. 25	1	0. 0683	0. 03
2	do	1	. 0985	1. 25	1	. 0985	. 04
3	Mechanical	1	. 0683	1. 25	1	. 0683	. 02
2	do	1	. 0985	1. 25	1	. 0985	. 02

been reduced in recent years because many of the new containers cannot sustain the weight of superimposed loads. As a result, the full potential of the forklift pallet system is unused. Some wholesalers have installed special supports on the pallets so the weight of the upper load is transmitted directly to the lower pallet or the floor instead of being placed on the packages stored on the pallet below. Pallet racks have also been introduced to make use of all vertical space except that taken by the racks themselves. Research on these pallet support systems is now under way; the results will be published in a later report.

Three powered units were studied. These were (1) the pallet transporters, (2) the high-lift pallet transporters, and (3) the large, counterbalanced, forklift truck (figs. 21, 22, and 24).

The worker usually walks in front of the high-lift pallet transporter while he operates it. Some recent models are designed so that the worker can sit on the battery case while he operates the equipment.

It is frequently difficult to move heavy power equipment, such as a forklift truck, into and out of carriers. Often the bed of a truck or the floor racks in refrigerated railroad cars cannot support the concentrated wheel loads of the forklift truck. In recent years, however, both trucks and railroad cars have been designed to sustain much heavier loads. Recently constructed refrigerated railroad cars have doors that are wide enough for fork trucks. When older carrier equipment is used, pallet loads are often picked up on the receiving platform of the warehouse. Labor requirement tables have been developed for this method as well as for the method where the pallet is picked up inside the carrier.

Data on pallet loading in the carrier, as well as forklift truck and pallet transporter operations on the dock and in the warehouse, were obtained by time study measurement.

However, because few of the newer trucks and railroad cars were available, it was not possible to make studies on high-lift transporter and forklift truck movement into and out of the carriers. Data on these operations were taken from other research sources. Consequently, time requirements for the elements that could not be measured are simulated. Thus, the labor requirement tables give a reliable estimate of the man-hours required when the newer equipment is used.

On the Platform

Labor requirements were the same when either the high-lift pallet transporter or the forklift truck picked up a loaded pallet on the platform, moved it, and placed it in the storage area. A three-man crew was organized so that three men set up and cleaned up; then two men positioned a pallet on a pallet dolly in the carrier, loaded the pallet and moved it onto the platform,

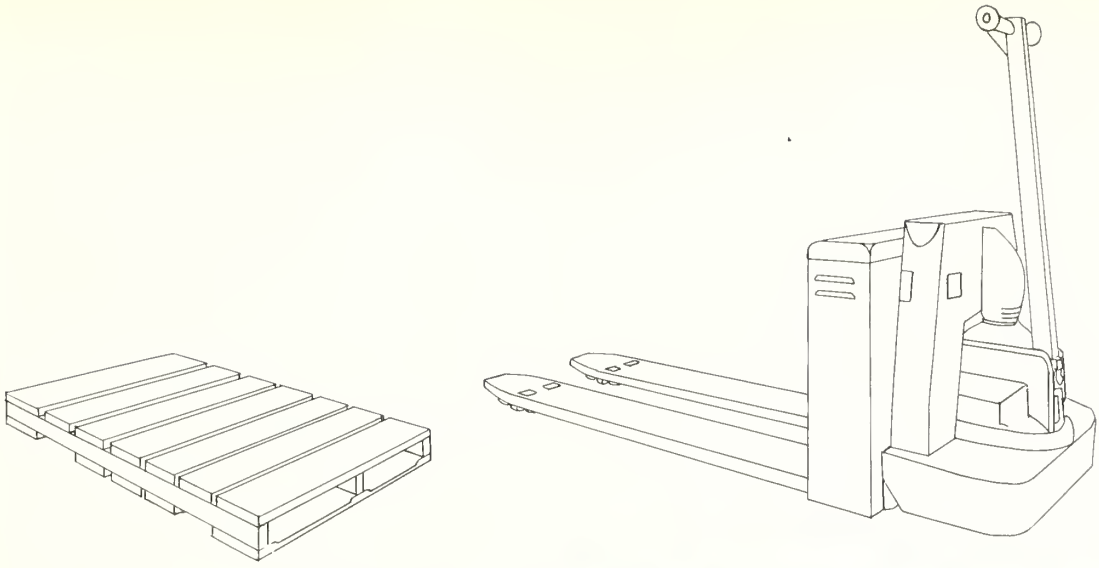

FIGURE 21.—Pallet and electric pallet transporter.

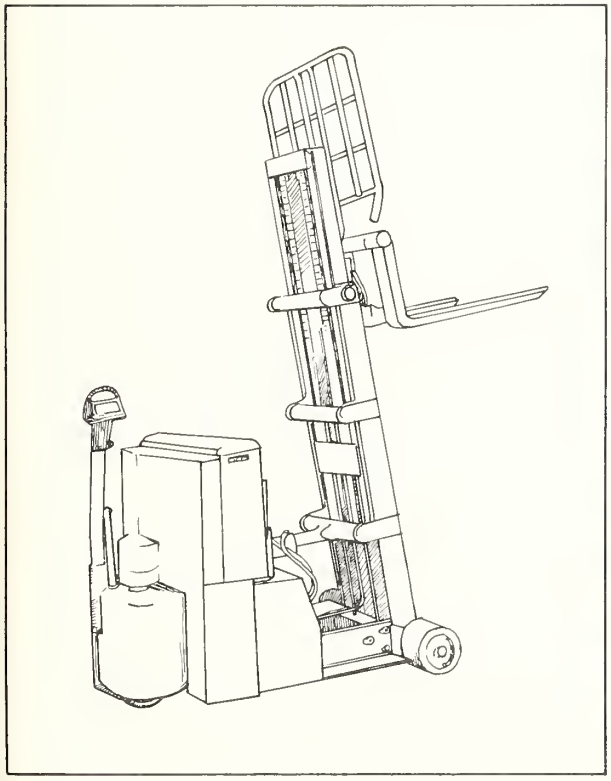

FIGURE 22.—Electric high-lift pallet transporter.

and one man picked up, transported, and set the load in storage and returned to the carrier. Placing pallets in storage included elevating the pallets and setting them in the second tier (on top of a pallet load on the floor). Forty 40-pound cartons (0.8 ton) were carried in each load. Total man-hour per ton was 0.220 for the 3-man crew (table 13).

FIGURE 23.—Loading packages on a pallet in a refrigerated railroad car.

A two-man crew was organized with both men setting up and later cleaning up. One man positioned pallets on a dolly and then loaded the pallets (fig. 23). The operator of the forklift truck or transporter helped to move the pallet from the carrier onto the platform. The transporter moved the load, set it in storage, and then returned to the carrier (figs. 25 and 26). The equipment operator supplied the loader with empty pallets. He picked up a stack of empty pallets and placed them near the carrier threshold

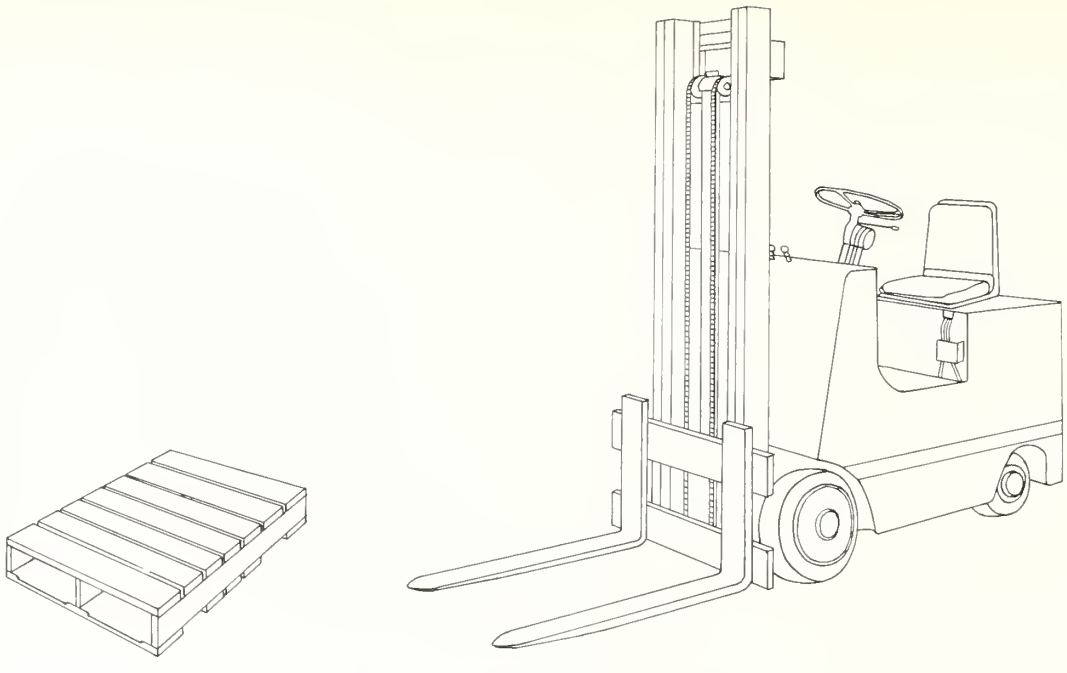

FIGURE 24.—Pallet and forklift truck.

TABLE 13.—*Labor required to receive 1 ton of produce in 40-pound packages with pallets and a forklift truck or high-lift transporter and specified crew organizations when loaded pallets were positioned for pickup on the platform* [1]

Time item	3-man crew [2]		2-man crew [3]	
	Workers	Labor required	Workers	Labor required
Productive labor:	*Number*	*Man-hours*	*Number*	*Man-hours*
Set up and clean up	3	0. 006	2	0. 007
Position pallet for loading	2	. 014	1	. 013
Load pallet	2	. 121	1	. 083
Position pallet for pickup	2	. 008	2	. 008
Pick up load on platform	1	. 004	1	. 004
Transport [4]	1	. 019	1	. 019
Set down loaded pallet	1	. 006	1	. 006
Total productive labor		. 178		. 140
Unproductive labor:				
Transporter waits for loaders	1	. 042	1	. 067
Total unproductive labor		. 042		. 067
Total labor	3	. 220	2	. 207
Elapsed hours		. 0733		. 1035

[1] Forty 40-pound packages loaded on each 48- by 40-inch pallet = 0.80 ton.

[2] Crew organization: 3 men set up and clean up; 2 men position and load pallets in carrier, then position loads on platform, and 1 transports loads to storage.

[3] Crew organization: 2 men set up and clean up; 1 man positions and loads pallets in carrier, then helps transporter position on platform, and 1 transports loads to storage.

[4] Transport loaded pallets to storage and return to carrier empty; one-way distance is 100 feet.

as they were needed. Labor requirements for the two-man crew total 0.207 man-hour (table 13).

When the carrier is unloaded, the first few pallets are loaded while they are on the platform. Subsequently, the empty pallets are moved into the carrier and placed as close as possible to the stacked packages. Keeping pallets and skids close to the workface minimizes the walking required

FIGURE 25.—Using a forklift truck to transport a pallet load to storage.

FIGURE 26.—Setting a pallet load in a second tier.

to load the pallet or skid. Labor requirement determinations are based on the fact that the pallet is adjacent to the workface.

In the Carrier

The work of moving the pallet on a pallet dolly between the carrier and the platform was eliminated when the forklift truck or the high-lift pallet transporter moved into the carrier to pick up the loaded pallets. When this work was eliminated, crew sizes remained the same but the total labor requirement was reduced. Total labor was 0.205 man-hour per ton when a forklift truck and a three-man crew were used (table 14). A transporter with the same crew size would require 0.206 man-hour per ton (table 15).

TABLE 14.—*Labor required to receive 1 ton of produce in 40-pound packages with pallets and a forklift truck and specified crew organizations when the loads were picked up in the carrier* [1]

Time item	3-man crew [2]		2-man crew [3]	
	Workers	Labor required	Workers	Labor required
Productive labor:	*Number*	*Man-hours*	*Number*	*Man-hours*
Set up and clean up	3	0.006	2	0.007
Position pallet for loading	2	.012	1	.012
Load pallet	2	.121	1	.083
Pick up loaded pallet and move out of carrier	1	.012	1	.012
Transport [4]	1	.019	1	.019
Set down loaded pallet	1	.006	1	.006
Total productive labor		.176		.139
Unproductive labor:				
Transporter waits for loaders	1	.029	1	.058
Total unproductive labor		.029		.058
Total labor		.205		.197
Elapsed hours		.0685		.0985

[1] Forty 40-pound packages loaded on each 48- by 40-inch pallet = 0.80 ton.

[2] Crew organization: 3 men set up and clean up; 2 men position and load pallets in carrier, and 1 removes loaded pallets from carrier with forklift truck and transports loads to storage.

[3] Crew organization: 2 men set up and clean up; 1 man positions and loads pallets in carrier, and 1 removes loaded pallets from carrier with forklift truck and transports loads to storage.

[4] Transport loaded pallets to storage and return to carrier empty; one-way distance is 100 feet.

TABLE 15.—*Labor required to receive 1 ton of produce in 40-pound packages with pallets and a high-lift transporter and specified crew organizations when the loads were picked up in the carrier* [1]

Time item	3-man crew [2]		2-man crew [3]	
	Workers	Labor required	Workers	Labor required
Productive labor:	*Number*	*Man-hours*	*Number*	*Man-hours*
Set up and clean up	3	0.006	2	0.007
Position pallet for loading	2	.012	1	.012
Load pallet	2	.121	1	.083
Enter carrier	1	.003	1	.003
Pick up load and leave carrier	1	.007	1	.007
Transport [4]	1	.019	1	.019
Set down load	1	.004	1	.004
Total productive labor		.172		.135
Unproductive labor:				
Transporter waits for loaders	1	.034	1	.062
Total unproductive labor		.034		.062
Total labor	3	.206	2	.197
Elapsed hours		.0685		.0985

[1] Forty 40-pound packages loaded on each 48- by 40-inch pallet = 0.80 ton.

[2] Crew organization: 3 men set up and clean up; 2 men position and load pallets in carrier, and 1 removes loaded pallets from carrier with high-lift transporter and transports loads to storage.

[3] Crew organization: 2 men set up and clean up; 1 man positions and loads pallets in carrier, and 1 removes loaded pallets from carrier with high-lift transporter and transports loads to storage.

[4] Transport loaded pallets to storage and return to carrier empty; one-way distance is 100 feet.

A two-man crew using a forklift truck or a high-lift pallet transporter required 0.197 man-hour for each ton unloaded and placed in storage (tables 14 and 15).

Labor and equipment costs were tabulated separately by type of equipment. Table 16 shows costs with the forklift truck. When the pallet loads were picked up on the platform during receiving, labor and equipment costs were $0.52 per ton for both the three- and the two-man crews. When loads were picked up in the carrier by the forklift truck, the cost was $0.49 per ton for a two-man crew and $0.47 per ton for a three-man crew.

Table 17 shows costs for the high-lift pallet transporter operation. When loads were picked up on the platform, costs for labor and use of equipment were $0.49 per ton. When the transporter moved into the carrier to pick up loads, costs were $0.47 per ton for a two-man crew, and $0.46 per ton for a three-man crew.

The lower elapsed time with the three-man crew resulted in a lower equipment cost per ton for both types of equipment. Total costs were lowest for each type of equipment when it picked up the load in the carrier.

Floor Area Requirements

The equipment and storage methods that are used in a wholesale warehouse affect the amount of floor space that is required. The cost, per ton of produce, for providing that space must be considered in determining the lowest cost system of handling and storage.

Data were available for a representative inventory of fruits and vegetables handled by a wholesaler with an annual volume equivalent to approximately 1,000 carloads. Space for this inventory was reduced to number of square feet for each ton handled. These ratios (square feet per ton) were developed so they could be applicable to both larger and smaller volumes of produce handled. The appendix shows details of the data used and the calculations made for the comparison of space requirements for each method and type of equipment.

The assumed rate of inventory turnover was once every 4½ days, or approximately 80 times per year. In 1 year, the turnover rate makes it possible to store 80 tons of produce in the space required by 1 ton. The cost of warehouse space per average storage period is a little over $0.01 per square foot (table 18).

The space requirements indicated in table 19 vary from 14 to 29 square feet per ton. The costs for this space range from $0.19 to $0.39 per ton. Two-wheel handtrucks require a minimum of aisle space, and hand-stacking makes the most efficient

TABLE 16.—*Labor and equipment costs for receiving 1 ton of produce in 40-pound packages when pallets and electric forklift trucks and various methods and crew sizes were used*

Method	Crew size	Elapsed time	Labor required	Labor and equipment costs		
				Labor [1]	Equipment [2]	Total
	Number	*Hours*	*Man-hours*	*Dollars*	*Dollars*	*Dollars*
2 workers position and load pallets in carrier and then position loaded pallets for pickup. Forklift operator picks up loaded pallets on platform and transports them 100 feet to storage	3	0. 0733	0. 220	0. 46	0. 06	0. 52
1 worker positions and loads pallets in carrier. Forklift operator helps loader position pallets for pickup, then picks up loaded pallets on platform and transports them 100 feet to storage	2	. 1035	. 207	. 44	. 08	. 52
1 worker positions and loads pallets in carrier. Forklift operator picks up loaded pallets in carrier and transports them 100 feet to storage	2	. 0985	. 197	. 42	. 07	. 49
2 workers position and load pallets in carrier. Forklift operator picks up loaded pallets in carrier and transports them 100 feet to storage	3	. 0685	. 205	. 42	. 05	. 47

[1] Labor costs are based on $2.25 per hour for forklift operators and $2 per hour for loaders and on the following labor requirements:

Labor required	Loaders	Forklift operators
Man-hours	*Man-hours*	*Man-hours*
0. 220	0. 146	0. 074
. 207	. 103	. 104
. 197	. 099	. 098
. 205	. 137	. 068

[2] Equipment costs are the product of machine-hours times the cost per hour of use for each equipment type as given in appendix tables 40 and 41. These costs are based on the following requirements:

Crew size	Elapsed time	Forklift trucks		Pallet dollies		Bridge plates		Pallets	Combined cost
Number	*Hours*	*Number*	*Machine-hours*	*Number*	*Machine-hours*	*Number*	*Machine-hours*	*Number*	*Dollars*
3	0. 0733	1	0. 073	1	0. 073	1	0. 073	1. 25	0. 06
2	. 1035	1	. 104	1	. 104	1	. 104	1. 25	. 08
2	. 0985	1	. 098	----------	----------	1	. 098	1. 25	. 07
3	. 0685	1	. 068	----------	----------	1	. 068	1. 25	. 05

use of storage space. Therefore, space requirements and storage costs are at a minimum when two-wheel handtrucks and hand-stacking are used.

Sixteen square feet per ton were required when semilive skids and the hand-stacking storage method were used. This space requirement, costing $0.22 per ton, was greater than that for handtrucks because wider aisles were required for semilive skids than for handtrucks.

When the unit-load method was used with two-wheel handtruck or clamp truck operations, the space requirement increased to 19 square feet per ton, at a cost of $0.26. The floor area increased because packages could not be stacked as compactly with unit-loading as with hand-stacking.

Usually, only one of every four loaded pallets could be stored on top of a pallet on the floor because the containers were not designed to support the weight. Thus, four pallet loads could be stored in floor space required for three pallets. This, plus the wide aisles that were needed, resulted in an area of 23 square feet and a cost of $0.31 per ton.

If pallet racks were used, the floor area per ton could be cut by approximately 40 percent. The cost per ton for storage space may also be reduced.

When semilive or dead skids were used to store the loads intact, 27 square feet per ton were required, at a cost of $0.36 per ton. Space requirements are greater for skids, even though aisle width is less, because skid loads cannot be placed one on top of the other to make use of the vertical space. If pallets had not been tiered, 29 square feet per ton would have been required, at a cost of $0.39 per ton.

TABLE 17.—*Labor and equipment costs for receiving 1 ton of produce in 40-pound packages when pallets and high-lift transporters and various methods and crew sizes were used*

Method	Crew size	Crew assignments		Elapsed time	Labor required	Labor and equipment costs		
		Loading	Transporting			Labor [1]	Equipment [2]	Total
	Number	*Number*	*Number*	*Hours*	*Man-hours*	*Dollars*	*Dollars*	*Dollars*
Loaders position pallet on dolly, load pallet in carrier, and position loaded pallet for pickup. Transporter picks up load on dolly and transports load 100 feet to storage area with high-lift transporter	3	2	1	0. 0733	0. 220	0. 45	0. 04	0. 49
	2	1	1	. 1035	. 207	. 44	. 05	. 49
Loaders position pallet manually and load pallet in carrier. Transporter enters carrier, picks up load, and transports load 100 feet to storage area with high-lift transporter	2	1	1	. 0985	. 197	. 42	. 05	. 47
	3	2	1	. 0685	. 172	. 42	. 04	. 46

[1] Labor costs are based on $2.25 per hour for forklift operator and $2 per hour for loaders and on the following labor requirements:

Labor required	Loaders	Forklift operator
Man-hours	*Man-hours*	*Man-hours*
0. 220	0. 147	0. 073
. 207	. 104	. 104
. 197	. 098	. 098
. 172	. 137	. 068

[2] Equipment costs are the product of machine-hours times the cost per hour of use for each equipment type as given in appendix tables 40 and 41. These costs are based on the following requirements:

Crew size	Elapsed time	Forklift transporter		Pallet dolly		Bridge plate		Pallets	Combined cost
Number	*Hours*	*Number*	*Machine-hours*	*Number*	*Machine-hours*	*Number*	*Machine-hours*	*Number*	*Dollars*
3	0. 0733	1	0. 073	1	0. 073	1	0. 073	1. 25	0. 04
2	. 1035	1	. 104	1	. 104	1	. 104	1. 25	. 05
2	. 0985	1	. 098			1	. 098	1. 25	. 05
3	. 0685	1	. 068			1	. 068	1. 25	. 04

TABLE 18.—*Cost to own and maintain a warehouse facility with an initial cost of $10 per square foot* [1] *and an expected life of 30 years*

Cost item	Cost per square foot
	Dollars
Annual cost:	
Depreciation [2]	0. 33
Average interest at 5 percent	. 25
Insurance and taxes at 4 percent	. 40
Maintenance at 1 percent	. 10
Total annual cost	1. 08
Daily cost (365 days)	. 0030
Cost per average storage period (4½ days)	. 0135

[1] Based on experience of members of United Fresh Fruit and Vegetable Association.
[2] Straight line depreciation.

TABLE 19.—*Floor area requirements and cost, to store 1 ton of fruits and vegetables, for specified equipment types and storage methods*

Equipment type	Storage method	Area required [1]	Cost [2]
		Square feet	*Dollars*
2-wheel handtruck	Hand-stack	14	0. 19
Semilive skid, 36- by 54-inch.	do	16	. 22
2-wheel handtruck	Tip off	19	. 26
Pallet, 48- by 40-inch	On pallet partial tiering.	23	. 31
Semilive or dead skid, 36- by 54-inch.	On skid	27	. 36
Pallet, 48- by 40- inch	On pallet, no tiering.	29	. 39

[1] See appendix for the basis for determining the number of square feet.
[2] The equivalent cost per square foot is $0.0135. See appendix for additional information on space costs.

Cost Comparisons by Equipment Type

Combining the cost for labor, equipment, and warehouse space provides the most realistic basis for comparing the costs for handling and storage methods (table 20). The crew arrangements that resulted in the lowest combined labor and equipment cost for each equipment type were selected The total cost shown was the lowest for each of the handling and storage systems.

Although hand-stacking made the best use of floor space, the added labor cost far exceeded the saving in space cost. When two-wheel handtrucks or clamp trucks were used in receiving and packages were hand-stacked in storage, the cost was $1.06 per ton. When semilive skids and jacks were used for receiving and hand-stacking was used for storage, the cost dropped to $0.88 per ton. This reduction occurred because the skid moved 0.80 ton per trip as against 0.12 ton for handtrucks or clamp trucks. Man-hours for transportation were less, thus reducing the total labor cost.

The semilive skid and jack system, with unit-loading for storage, incurred a cost of $0.83 per ton. Eliminating hand-stacking reduced the labor cost by $0.25 per ton. This was offset, in part, by a space cost increase of $0.14 per ton and an equipment cost increase of $0.06 per ton because more skids were required. When semilive skids were used, the net cost was reduced $0.05 per ton for the unit-load system below that for the hand-stacking system.

The high cost of hand-stacking in storage was eliminated when unit-loads were either tipped off or released intact by two-wheel handtrucks or clamp trucks. Costs dropped from $1.06 per ton to $0.82 per ton when two-wheel clamp trucks were used and to $0.80 per ton when two-wheel handtrucks were used.

Dead skids and electric low-lift platform trucks used with unit loads resulted in a total cost of $0.79 per ton. When pallets were partially tiered with electric forklift trucks, the total cost was $0.78 per ton. An identical pallet-handling system using an electric high-lift transporter cost $0.77 per ton.

The warehouse layout is a determining factor in the selection of materials-handling equipment. Electric-powered equipment requires more room to maneuver and also has highly concentrated wheel loads. The floors in many older warehouses would be too weak for powered truck operations. Numerous large columns, typical of old structures, would also make it difficult to use storage areas efficiently.

A wholesaler should adopt the receiving and storage method that results in the lowest *total* operating cost. If he must use manual two-wheel handtrucks or clamp trucks, he should avoid hand-stacking in storage. Total costs can be reduced as much as $0.26 per ton by changing from the hand-stacking to the tipoff load storage method. The reduction in labor cost alone would amount to $0.33 per ton.

When semilive skids and jacks are used, labor costs are $0.25 per ton less with the unit-load storage method than with the hand-stacking method. Total costs are reduced only $0.05 per ton because of higher equipment and storage charges.

The equipment with the lowest total cost for handling has a potential for greater storage efficiency and lower storage costs than are possible with the limitations imposed by present package designs and operating conditions. The forklift truck and the high-lift transporter each have the capacity to store pallet loads at least three high. If package strength were great enough, 12 pallets could be stored in the floor space taken by 4 pallets. In the system described, floor space was required for 9 pallets in order to store 12 pallets because

TABLE 20.—*Labor, equipment, and storage space costs for receiving and storing 1 ton of produce with specified types of materials-handling equipment and methods*

Equipment	Storage method	Crew size	Elapsed time	Labor cost	Equipment cost	Storage space cost	Total cost
		Number	*Hours*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
2-wheel handtruck or clamp trucks.	Hand-stacked	4	0. 108	0. 86	0. 01	0. 19	1. 06
Semilive skids and jack	do	3	. 108	. 65	. 01	. 22	. 88
Do	Stored on skids	2	. 101	. 40	. 07	. 36	. 83
2-wheel clamp trucks	Release load intact	3	. 092	. 55	. 01	. 26	. 82
2-wheel handtrucks	Tip off load intact	3	. 089	. 53	. 01	. 26	. 80
Dead skids and electric low-lift platform truck.	Stored on skids	2	. 098	. 39	. 04	. 36	. 79
Pallets and electric forklift truck	Stored on pallets, partial tiering.	3	. 068	. 42	. 05	. 31	. 78
Pallets and electric high-lift transporter.	do	3	. 068	. 42	. 04	. 31	. 77

only 3 of the 12 pallets could be placed on top of those on the floor. If three-pallet tiering were possible, floor space could be reduced by a little over 40 percent. However, present container construction does not permit this.

Research is under way to determine the cost of and to perfect devices that will tier pallets by supporting them independently of the loads below them. These tiering devices would help to achieve the full potential for storage efficiency in the pallet and lift truck handling systems. Some wholesalers are doing this now by using pallet racks and other types of supports that transmit the weight directly to the floor.

Other Factors Affecting Labor Requirements

Several factors can increase the labor requirements for receiving and storing fresh fruits and vegetables. One of these is poor supervision. Others are related to the product received. Some of the activities that increase labor requirements and handling costs are: using unbalanced crews; removing top ice or bracing and stripping; sorting produce for sizes or grades; and special handling for commodities such as watermelons.

A few factors may contribute to lower labor requirements. One would be the weight of the package received. As the weight increases from 30 to 100 pounds, the labor required for handling decreases for elements such as loading or hand-stacking.

Crew Balance and Interference

A balanced crew is achieved when the workers are selected and assigned in such a manner that idle time and crew interference are minimized. When the crew is too large or is out of balance, careful observations will enable management to lower labor costs by reducing the crew size by one man or more. Better balance and optimum productivity can be achieved when time studies by a trained observer are used to accurately measure productive and unproductive times. Detailed information obtained with this technique is used to adjust work assignments and crew size for increased productivity per crew member and minimum costs per ton handled. Unproductive time can rarely be eliminated completely, but it can be minimized when work assignments are well planned. The crew assignments and organizations in this report were designed for these objectives.

Crew interference reduces productivity. This usually occurs when one or more members of the crew cannot work until another crew member completes his job. Some delays from crew interference are short, but they become significant when they are accumulated. A good illustration is given in this tabulation:

Crew size:	*Total man-hours required per ton*
4	0. 244
3	. 186
2	. 121
1	. 083

The man-hours in this tabulation are for loading 1 ton of produce, received in 40-pound packages, on a dead skid. The man-hours per ton increase as the number of men (from one to four) assigned to loading each skid increases. Thus, the cost of receiving a ton of produce goes up as the number of men working on the same job goes up. It would cost almost three times as much for four men to do the job as it did for one man. Four men loading a skid must either handle each package twice by passing it from one man to the next or get in each other's way to such an extent that crew interference is excessive. The elapsed time to finish the job is less for four men than it is for one man, but a tripled labor cost is a high price to pay for the added speed.

Figure 27 illustrates the labor increase per ton for loading pallets or skids with packages ranging in weight from 30 to 100 pounds when the number of men assigned to this element increases from one to four.

Figure 28 shows a similar comparison for building loads for two-wheel handtrucks or two-wheel clamp trucks; the two upper lines in the figure indicate hand-stacking in storage when one man or two men were assigned to this work. Stacking height did not exceed 96 inches. Stacking takes longer than loading equipment because the packages are lifted higher and workplaces in storage rooms are usually more confined than those in the carriers.

Top Icing, Bracing, and Stripping

Some commodities arrive at the warehouse with top ice that has been sprayed through the load to maintain product quality. The top ice may be light, medium, or heavy, depending upon how much has melted in transit. As the carrier is unloaded, the ice must be removed so the packages are accessible for loading on the handling equipment. The melting ice causes sloppy, slippery working conditions. Additional time is required to shovel ice out of the carrier and to clear the work area. The average labor requirements for removing ice from a carrier that contains slightly more than 15 tons of produce are:

Ice condition:	*Man-hours per carload equivalent*
Light	0. 185
Medium	. 539
Heavy	1. 476

Shipments by rail often require bracing and stripping to prevent movement of the load in transit. When movement occurs, the container and the product are often damaged. Bracing is

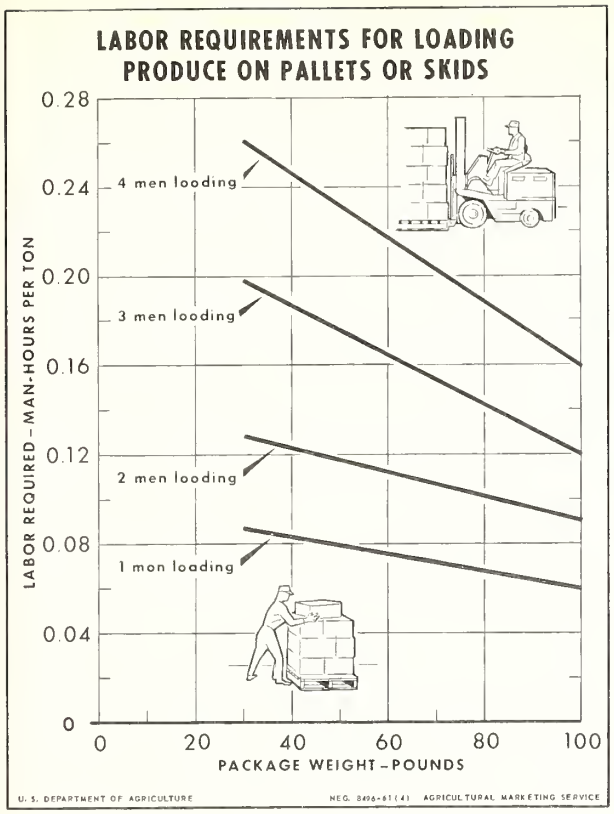

FIGURE 27.

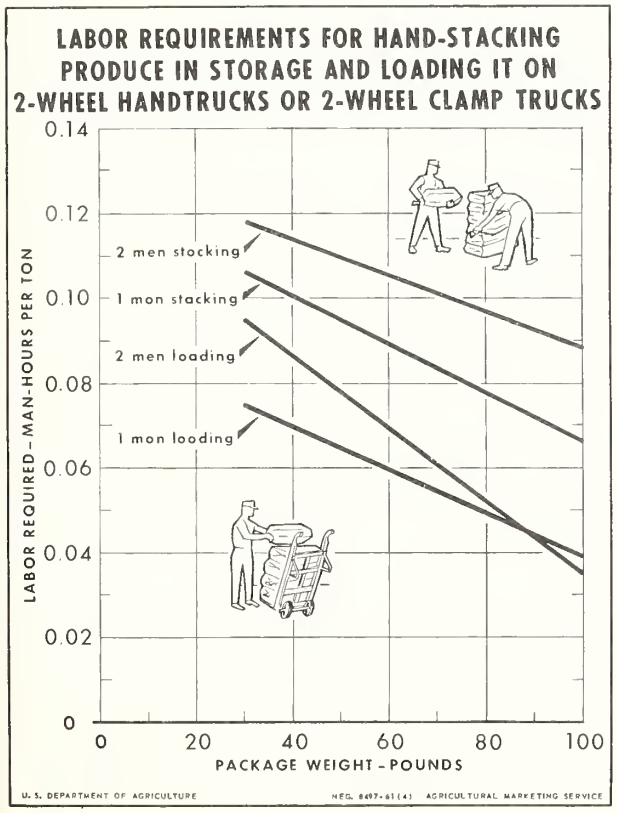

FIGURE 28.

FIGURE 29.—Railroad car with bracing partially removed.

usually a heavy timber framework built across the refrigerated railroad car between the doors. This framework must be removed prior to unloading (fig. 29). One man can remove the bracing from a railroad car in 0.110 man-hour.

Stripping gives further protection against load movement. Narrow wood strips are nailed to the wood containers of products, and interspersed throughout the load. Both horizontal and vertical stripping is used between stacks of packages. Removing the stripping while unloading a carrier takes 0.227 man-hour per carload equivalent.

Stripping may also be used in some truck shipments. The same amount of time is required per carload equivalent to remove stripping from a truck as from a refrigerated railroad car. Wood timber bracing is not used in trucks. Large pipe type clamps, which are quickly and easily removed, are used. This type of bracing can be removed during the time required for setup.

Transportation Distance

In tables 1 to 17, crew balance for receiving operations was based on a distance of 100 feet from the carrier to the storage point. This distance was considered typical for the arrangement of facilities in most wholesale warehouses. The wholesaler can locate the carrier to minimize the distance from the receiving dock to the storage point for each commodity.

In a warehouse with unusual shape or arrangement, the average transportation distance may exceed 100 feet. This will increase the time, per ton, for transporting loads. The labor requirements for using semilive skids, dead skids, and pallets indicated that the transporters were idle part of the time because their work required less time than the work of other members of the crew. Therefore, additional distances of 30 to 50 feet could be traversed without affecting the total

labor requirements. When the distance exceeds 130 feet, the crew might have to be adjusted for better balance of work.

The labor requirements for crews using two-wheel handtrucks or clamp trucks indicate that half of the suggested crew organizations have idle transporter time. For the other half, one or more workers must wait while the transporters complete their job.

Where the transporters are idle part of the time, the distance can be increased by 30 to 50 feet without affecting total labor requirements. But when the time required by added distance exceeds the available idle time, an additional transporter may be needed to balance the operation, thus increasing total labor requirements. Where the workers have to wait for the transporters, added distance will increase total labor requirements.

Package Weights

The pallet handling system can be used to illustrate how package weight affects labor requirements for a given element of work.

After a pallet has been positioned in a carrier, a worker walks to the workface, grasps a package, lifts and secures it, carries it to the pallet, positions it, and releases it on the pallet. He repeats this cycle until the pallet is fully loaded and then removed by the transporter.

The labor requirements for two men loading a pallet are:

Package weight	*Man-hours per ton*
30 pounds	0. 128
40 pounds	. 121
50 pounds	. 120
80 pounds	. 140
100 pounds	. 090

The decrease in man-hours per ton is caused by the decrease in number of work cycles required as the weight of the packages increases. Sixty-seven cycles of work are required to palletize a ton of a commodity received in 30-pound packages; only 20 such cycles per ton are required for 100-pound packages. As the tables in the appendix indicate, this relationship is true for all types of equipment and all crew sizes studied.

The effect of this reduced time is illustrated by the total time required to receive and store 1 ton of produce when the commodity is received in 100-pound packages. When pallets and a high-lift transporter were used, a three-man crew required a total of 0.156 man-hour per ton of 100-pound packages (table 21) and 0.206 man-hour per ton of 40-pound packages (table 15).

Miscellaneous Labor Requirements

When commodities such as apples and oranges are received, sorting for sizes and grades causes additional work and labor time. It was not possible to get accurate measurements of this added time, due to the variety of sizes and the great variations in the degree to which they were scattered throughout each load.

TABLE 21.—*Labor required to receive 1 ton of produce in 100-pound packages when pallets and a high-lift transporter and a 3-man crew were used*[1]

Time item	Workers	Labor required
Productive labor:	*Number*	*Man-hours*
Set up and clean up	3	0. 006
Position pallet for loading	2	. 010
Load pallet	2	. 090
Enter carrier	1	. 002
Pick up load and leave carrier	1	. 006
Transport [2]	1	. 015
Set down load	1	. 003
Total productive labor		. 132
Unproductive labor:		
Transporter waits for loaders	1	. 024
Total unproductive labor		. 024
Total labor	3	. 156
Elapsed hours		. 0520

[1] 20 100-pound packages loaded on each 48- by 40-inch pallet = 1.00 ton. Crew organization: 3 men set up and clean up; 2 men position and load pallets in carrier, and 1 man transports loads to storage.

[2] Transport loaded pallet to storage and return to carrier empty; 1-way distance is 100 feet.

The wholesaler sells by size. When a mixture of sizes is received, packages must be sorted and sizes segregated for subsequent assembly and truck loading operations. Separate stacks of each size are built on the carrier floor or on separate skids or pallets. The resulting break in routine and the need to read size identifications and to segregate the sizes makes the job more difficult and time-consuming. The most productive operation can be achieved when loaders are experienced men who know the meaning of size or grade designations and can locate and read the size numbers easily. Total labor is greater for receiving sized commodities than for those not sized. The added time will depend upon the competence of the loaders and the extent to which various sizes are mixed in the load.

During the watermelon season, additional work is required at the wholesale level because of the varied sizes and the difficulty in handling. Handling practices vary widely. The practice followed is sometimes affected by the merchandising methods used.

For example, some wholesalers sell by size as well as by the pound. Each watermelon is weighed and marked, and separated into groups of large, medium, and small melons. Some are manually handled and stacked on the warehouse floor. Others are placed in banana boxes or skid or pallet boxes and stacked in storage. Properly designed boxes reduce manual handling

and permit use of vertical storage space. Since watermelons are a highly competitive commodity and have modest price markups, the wholesaler should make every effort to adjust his merchandising practices to permit low-cost handling. Using containers—whether they are field crates, banana, skid, or pallet boxes—will help keep labor costs down.

The special problems of handling and storing bananas have been presented in another report.[2] The methods and types of equipment used are presented and evaluated therein.

Appendix

Research Methods and Techniques

Receiving and storage operations were observed in the warehouses of wholesale distributors of fresh fruits and vegetables. Time studies were made of these operations during the working hours and under the conditions that are commonly found to exist in the industry. The equipment types were representative of those most often used by wholesalers to receive and store commodities.

Time study techniques were used to carefully record the major elements of work that were performed. Each member of the crew assigned to work on receiving or storage operations was studied. A decimal-minute stopwatch was used to record the time. As a worker was studied, the observer recorded the time required for each element of work.

Delays were recorded and identified to determine their cause. All delays classed as avoidable have been removed from the time requirements established for the work. Unavoidable delays such as crew interference are included in the total labor requirements for each operation. These latter delays are incurred as a result of the method used or the number of men assigned to do a particular job.

During the course of recording data for a time study, a trained observer made an estimate of the effort level of the man being studied. The effort level was expressed as a percentage. The basis for comparison was a normal performance level of 100 percent. This is a measure of the effort that an experienced worker is expected to put forth in the normal execution of his assigned duties. In observing a worker, the time-study man compared the worker's effort with a normal performance. He then recorded a percent which was higher, lower, or equal to the normal rate. A higher rate would mean that a man was more productive than normal. A lower rate would indicate a lower level of productivity than normal. The observed time was multiplied by the assigned percent effort level to convert it to the time that would be required if the worker studied had performed at a normal pace. The resulting time value is known as the *base time.*

The time values used in this report are productive times. The *productive time* is equal to the base time plus allowances for fatigue and personal needs. The *fatigue* allowance is included to provide time for the assigned worker to rest to overcome the fatigue resulting from sustained physical effort. The percent value used for the fatigue allowance is directly related to physical difficulty and the working conditions associated with an assigned job. Five percent is the value assigned for *personal needs.* This percent is generally accepted as being adequate for worker comfort. In an 8-hour workday it would provide a total of 24 minutes.

The productive times developed in this manner provide a sound basis for comparison of crew sizes, methods, and equipment types. Studies in different parts of the United States indicate that labor productivity varies from one locality to another. This variation has been observed from one city to another within the same State. Therefore, the observed time was corrected to base time so that the data obtained in one community were comparable with those obtained in another. The addition of fatigue and personal allowances to the base time results in the productive time. The final value can be used as a guide to the minimum labor force necessary for a given business volume, method of operation, and equipment type. Productive times can be found in tables 22 through 39

Equipment Costs

In many cases, materials-handling equipment was used for both receiving and loading-out operations. Where this was true, half of the initial cost of the equipment was charged to the receiving operation and half to the loading-out operation. In this way each operation was charged to the extent that the equipment was used in that activity. It was estimated that the handling units would be employed for 2,000 hours a year on receiving and 2,000 hours a year on loading out.

The initial cost of equipment indicated in tables 40 and 41 was based on data supplied by manufacturers. It was f.o.b. at their plants. The figures were current for the year 1960.

[2] Andrews, B. G., and Burt, S. W. Methods, Equipment, and Facilities for Receiving, Ripening, and Packing Bananas. U.S. Dept. Agr. Mktg. Res. Rpt. 92, 127 pp., 1955.

TABLE 22.—*Labor required for 1-man or 2-man loading, 1 ton of produce in packages of specified sizes, in carrier, on 2-wheel handtrucks or clamp trucks*

Element description and size of package	1-man			2-man		
	Base time	Allowances	Productive time	Base time	Allowances	Productive time
Load in carrier: Begins when worker starts toward workface. Includes walking to workface, grasping package, lifting and securing package, carrying to handtruck or pickup point, positioning and releasing in load, and returning for next package. Ends when last package is released in position in the load.	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*
30-pound packages	0. 065	0. 010	0. 075	0. 083	0. 012	0. 095
40-pound packages	. 060	. 009	. 069	. 075	. 011	. 086
50-pound packages	. 055	. 011	. 066	. 067	. 013	. 080
80-pound packages	. 041	. 010	. 051	. 044	. 011	. 055
100-pound packages	. 031	. 008	. 039	. 028	. 007	. 035

TABLE 23.—*Labor required for 1-man or 2-man hand-stacking 1 ton of produce, in packages of specified sizes, in storage stacks up to 9 feet high*

Element description and size of package	1-man			2-man		
	Base time	Allowances	Productive time	Base time	Allowances	Productive time
Hand-stack: Begins when worker starts toward loaded equipment. Includes walking to load, grasping package, lifting and securing package, carrying to stack, positioning and releasing in stack, and returning for next package. Ends when last package is released in position in the stack.	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*
30-pound packages	0. 094	0. 019	0. 113	0. 098	0. 020	0. 118
40-pound packages	. 088	. 018	. 106	. 094	. 019	. 113
50-pound packages	. 082	. 020	. 102	. 090	. 022	. 112
80-pound packages	. 063	. 019	. 082	. 077	. 023	. 100
100-pound packages	. 051	. 015	. 066	. 068	. 020	. 088

TABLE 24.—*Labor required for 1-man or 2-man loading, 1 ton of produce, in packages of specified sizes, in carrier, on semilive skids, dead skids, or pallets*

Element description and size of package	1-man			2-man		
	Base time	Allowances	Productive time	Base time	Allowances	Productive time
Load in carrier: Begins when worker starts toward workface. Includes walking to workface, grasping package, lifting and securing package, carrying to skid or pallet, positioning and releasing in load and returning for next package. Ends when last package is released in position in the load.	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*
30-pound packages	0. 076	0. 011	0. 087	0. 111	0. 017	0. 128
40-pound packages	. 072	. 011	. 083	. 105	. 016	. 121
50-pound packages	. 068	. 014	. 082	. 100	. 020	. 120
80-pound packages	. 056	. 014	. 070	. 083	. 021	. 104
100-pound packages	. 048	. 012	. 060	. 072	. 018	. 090

TABLE 25.—*Labor required for 3 men or 4 men loading 1 ton of produce, in packages of specified sizes, in carrier, on semilive skids, dead skids, or pallets*

Element description and size of package	3 men			4 men		
	Base time	Allowances	Productive time	Base time	Allowances	Productive time
Load in carrier: Begins when worker starts toward workface. Includes walking to workface, grasping package, lifting and securing package, carrying to skid or pallet, positioning and releasing in load, and returning for next package. Ends when last package is released in position in the load.	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*
30-pound packages	0. 172	0. 026	0. 198	0. 228	0. 034	. 262
40-pound packages	. 162	. 024	. 186	. 212	. 032	. 244
50-pound packages	. 151	. 030	. 181	. 198	. 040	. 238
80-pound packages	. 118	. 030	. 148	. 155	. 039	. 194
100-pound packages	. 096	. 024	. 120	. 127	. 032	. 159

TABLE 26.—*Labor required*, per occurrence, *for receiving elements when 2-wheel handtrucks were used*

Element description	Workers in crew	Base labor	Allowances	Productive labor
Enter carrier: Begins when empty handtruck contacts bridge plate. Includes crossing bridge plate, transporting empty handtruck to pick up point, placing it in proper position, and releasing empty handtruck. Ends when worker releases empty handtruck or when transporter starts to position handtruck to engage load	*Number* 1	*Man-hours* 0. 0008	*Man-hours* 0. 0001	*Man-hours* 0. 0009
Pick up load:				
1. Pick up loaded handtruck (transporter waits for handtruck to be loaded). Begins when worker starts toward loaded handtruck. Includes walking to loaded handtruck, grasping handles, tilting load, starting to move load, and moving load clear of original position. Ends when load clears original position	1	. 0006	. 0001	. 0007
2. Exchange empty for loaded handtruck: Begins when worker starts to position empty handtruck for set down. Includes positioning and releasing empty handtruck, walking to loaded handtruck, grasping handles, tilting load, starting to move load, and moving clear of original position. Ends when load clears original position	1	. 0011	. 0002	. 0013
3. Tip on load: Begins when transporter starts to position handtruck to engage load. Includes tilting load forward, pushing shoe of handtruck under bottom package, tilting load back, and clearing original position. Ends when load clears original position	1	. 0013	. 0002	. 0015
Leave carrier: Begins when load clears original position. Includes transporting load to and crossing bridge plate. Ends when load clears bridge plate	1	. 0019	. 0003	. 0022
Set down loaded handtruck: Begins when transporter starts to position loaded handtruck for set down. Includes positioning and releasing loaded handtruck. Ends when loaded handtruck is released	1	. 0006	. 0001	. 0007
Tip off load: Begins when transporter starts to position loaded handtruck for tipoff. Includes positioning load, tipping load forward, withdrawing shoe of handtruck, and clearing load. Ends when shoe of handtruck clears face of load	1	. 0016	. 0002	. 0018
Exchange loaded for empty handtruck: Begins when worker starts to position loaded handtruck for set-down. Includes positioning and releasing loaded handtruck, walking to empty handtruck, grasping handles, starting to move empty handtruck, and moving clear of original position. Ends when empty handtruck clears original position	1	. 0027	. 0004	. 0031
Pick up empty handtruck: Begins when worker starts toward empty handtruck. Includes walking to empty handtruck, grasping handles, starting to move handtruck, and clearing original position. Ends when empty handtruck clears original position	1	. 0003	. 0001	. 0004
Set down empty handtruck: Begins when worker starts to position empty handtruck. Includes positioning and releasing handtruck. Ends when handtruck is released	1	. 0004	. 0001	. 0005

TABLE 27.—*Labor required*, per occurrence, *for receiving elements when 2-wheel clamp trucks were used*

Element description	Workers in crew	Base labor	Allowances	Productive labor
	Number	*Man-hours*	*Man-hours*	*Man-hours*
Enter carrier: Begins when empty clamp truck contacts bridge plate. Includes crossing bridge plate, transporting empty clamp truck to pickup point, and placing it in position. Ends when clamps start to pass face of load	1	0. 0008	0. 0001	0. 0009
Pick up load: Begins when clamps start to pass face of load. Includes positioning clamps about load, engaging clamps, tilting load, starting to move load, and moving load clear of original position. Ends when load clears original position	1	. 0021	. 0004	. 0025
Leave carrier: Begins when load clears original position. Includes transporting load to and crossing bridge plate. Ends when load clears bridge plate	1	. 0019	. 0003	. 0022
Release load: Begins when worker starts to position loaded clamp truck in storage area. Includes positioning load, releasing clamps, and withdrawing clamps. Ends when empty clamps clear face of load	1	. 0011	. 0002	. 0013
Preposition stack of packages for 2-wheel clamp truck pickup: Begins when worker starts toward workface. Includes walking to workface, positioning hook on bottom package, and pulling stack of packages into position for pickup. Ends when worker removes hook from stack of packages	1	. 0033	. 0008	. 0041
Pick up empty 2-wheel clamp truck: Begins when worker starts toward empty clamp truck. Includes walking to empty clamp truck, grasping handles starting to move clamp truck, and clearing original position. Ends when empty clamp truck clears original position	1	. 0003	. 0001	. 0004

TABLE 28.—*Labor required*, per occurrence, *for receiving elements when semilive skids and jacks were used*

Element description	Workers in crew	Base labor	Allowances	Productive labor
	Number	*Man-hours*	*Man-hours*	*Man-hours*
Position skid for loading: Begins when worker starts toward empty skid. Includes walking to empty skid, lifting, transporting an average distance of 24 feet, and placing in position for loading. Ends when skid has been released	1	0. 0046	0. 0012	0. 0058
Enter carrier: Begins when jack-lift contacts bridge plate. Includes transporting jack-lift into carrier. Ends when jack-lift touches skid	1	. 0026	. 0004	. 0030
Pick up load: Begins when jack-lift touches skid. Includes positioning and engaging jack, starting to move skid, and moving skid clear of original position. Ends when skid clears original position	1	. 0023	. 0005	. 0028
	2	. 0032	. 0005	. 0037
Pick up empty skid: Begins when jack-lift touches skid. Includes positioning and engaging jack, starting to move skid, and moving skid clear of original position. Ends when skid clears original position	1	. 0023	. 0002	. 0025
Leave carrier: Begins when skid clears original position. Includes transporting skid to and crossing bridge plate. Ends when skid clears bridge plate	1	. 0029	. 0006	. 0035
	2	. 0072	. 0011	. 0083
Set down load: Begins when transporter starts to position loaded skid at setdown point. Includes positioning and releasing loaded skid. Ends when loaded skid is released	1	. 0037	. 0009	. 0046
	2	. 0046	. 0012	. 0058
Set down empty skid: Begins when transporter starts to position empty skid at setdown point. Includes positioning and releasing empty skid. Ends when empty skid is released	1	. 0037	. 0004	. 0041

TABLE 29.—*Labor required,* per occurrence, *for receiving elements when dead skids and low-lift platform trucks were used*

Element description	Workers in crew	Base labor	Allowances	Productive labor
	Number	*Man-hours*	*Man-hours*	*Man-hours*
Position skid for loading: Begins when worker starts toward empty skid. Includes walking to empty skid, lifting, transporting an average distance of 24 feet, and placing skid in position for loading. Ends when skid has been released.				
1. Manually	1	0.0078	0.0020	0.0098
2. Manually	2	.0085	.0013	.0098
3. Manual platform truck (ends when skid is in position on floor)	1	.0069	.0010	.0079
4. Electric platform truck (ends when skid is in position on floor)	1	.0070	.0007	.0077
Enter carrier: Begins when transporter contacts bridge plate. Includes crossing bridge plate, transporting to pickup point, and alining truck to move under loaded skid. Ends when truck is backed against loaded skid.				
1. Manual platform truck	1	.0028	.0004	.0032
2. Electric platform truck	1	.0023	.0002	.0025
Pick up loaded skid: Begins when truck is backed against loaded skid. Includes elevating skid for movement. Ends when loaded skid is clear of floor and ready to move.				
1. Manual platform truck, mechanical	1	.0021	.0004	.0025
2. Manual platform truck, hydraulic	1	.0067	.0013	.0080
3. Electric platform truck	1	.0027	.0003	.0030
Leave carrier: Begins when skid is clear of floor and ready to move. Includes moving skid clear of original position, maneuvering it when necessary in order to cross threshold of carrier and bridge plate, transporting skid to and crossing bridge plate. Ends when skid clears bridge plate.				
1. Manual platform truck	1	.0030	.0006	.0036
2. Electric platform truck	1	.0025	.0002	.0027
Position loaded skid for setdown: Begins when transporter starts maneuvering skid for setdown. Includes turning and pushing or pulling truck to aline skid for setdown. Ends when transporter touches lowering control.				
1. Manual platform truck	1	.0072	.0018	.0090
2. Electric platform truck	1	.0038	.0004	.0042
Set down loaded skid: Begins when transporter touches lowering control. Includes lowering skid to floor, and moving truck out from under skid. Ends when truck clears skid.				
1. Manual platform truck, mechanical	1	.0014	.0003	.0017
2. Manual platform truck, hydraulic	1	.0032	.0008	.0040
3. Electric platform truck	1	.0011	.0001	.0012
Position truck to pick up load: Begins when transporter starts maneuvering truck for pickup. Includes turning and pushing or pulling truck, and positioning truck under skid. Ends when truck is backed against skid.				
1. Manual platform truck	1	.0043	.0006	.0049
2. Electric platform truck	1	.0015	.0002	.0017

TABLE 30.—*Labor required*, per occurrence *for receiving elements when pallets and powered pallet transporters were used*

Element description	Workers in crew	Base labor	Allowances	Productive labor
	Number	*Man-hours*	*Man-hours*	*Man-hours*
Position pallet for loading: Begins when worker starts toward empty pallet. Includes walking to empty pallet, lifting, transporting an average distance of 24 feet, placing in position for loading. Ends when pallet has been released	1	0. 0078	0. 0020	0. 0098
Position pallet for loading with pallet transporter: Begins when worker starts toward empty pallet. Includes walking to empty pallet, positioning it for pickup where necessary, returning to transporter, positioning transporter under pallet, lifting pallet, transporting pallet an average distance of 24 feet to position in carrier, and lowering pallet in position. Ends when worker releases the lowering control	1	. 0117	. 0012	. 0129
Enter carrier: Begins when transporter contacts bridge plate. Includes crossing bridge plate, transporting to pickup point, and alining transporter to move under loaded pallet. Ends when transporter is backed against loaded pallet	1	. 0023	. 0002	. 0025
Pick up load and leave carrier: Begins when transporter is backed against loaded pallet or when worker starts toward transporter under loaded pallet. Includes walking to transporter, lifting loaded pallet, transporting loaded pallet to bridge plate, and crossing bridge plate. Ends when load clears bridge plate	1	. 0050	. 0005	. 0055
Pick up load on platform: Begins when forks start to enter pallet. Includes inserting forks into pallet, lifting pallet, and moving load clear of original position. Ends when load clears original position	1	. 0018	. 0002	. 0020
Set down load: Begins when transporter starts to position loaded pallet at setdown point. Includes positioning pallet, depositing pallet, and starting backward motion. Ends when forks clear face of load	1	. 0026	. 0003	. 0029

TABLE 31.—*Labor required*, per occurrence, *for receiving elements when pallets and forklift trucks were used*

Element description	Workers in crew	Base labor	Allowances	Productive labor
	Number	*Man-hours*	*Man-hour*	*Man-hours*
Position pallet for loading: Begins when worker starts toward empty pallet. Includes walking to empty pallet, lifting, placing on pallet dolly, and pushing pallet an average distance of 24 feet into position for loading. Ends when pallet has been released	1	0. 0090	0. 0013	0. 0103
	2	. 0100	. 0010	. 0110
Position pallet for pickup: Begins when worker starts toward loaded pallet or pallet dolly. Includes pushing loaded pallet an average distance of 14 feet to threshold, and placing in position for pickup. Ends when loaded pallet is released in position for pickup	1	. 0030	. 0006	. 0036
	2	. 0056	. 0008	. 0064
Pick up loaded pallet and move out of carrier: Begins when forks start to enter pallet or when fork truck contacts bridge plate. Includes elevating load, moving it out of its original position, and crossing threshold of carrier and bridge plate. Ends when load clears bridge plate, or is set down on platform for later transporting	1	. 0086	. 0009	. 0095
Pick up load on platform: Begins when forks start to enter pallet. Includes inserting forks, lifting and tilting pallet, and moving load clear of original position. Ends when load clears original position	1	. 0027	. 0003	. 0030
Set down loaded pallet: Begins when fork truck starts to position loaded pallet at setdown point. Includes positioning pallet, elevating when necessary, tilting mast forward, depositing pallet, and starting backward motion. Ends when forks clear face of load.				
1. First tier setdown	1	. 0040	. 0004	. 0044
2. Second tier setdown	2	. 0045	. 0004	. 0049

TABLE 32.—*Labor required, per trip, for 1 man transporting produce to storage area and returning to carrier, with empty equipment, when 2-wheel handtrucks or 2-wheel clamp trucks were used*

Element description	Distance [1]	Base time	Allowances	Productive time
	Feet	*Man-hours*	*Man-hours*	*Man-hours*
Transport loaded and return empty: Begins when load clears bridge plate or original position on platform. Includes transporting loaded equipment to storage area and returning to carrier, with empty equipment. Ends when truck contacts bridge plate or when transporter stops on platform.	10	0. 0012	0. 0002	0. 0014
	20	. 0025	. 0004	. 0029
	30	. 0038	. 0006	. 0044
	40	. 0051	. 0007	. 0058
	50	. 0063	. 0010	. 0073
	60	. 0076	. 0012	. 0088
	70	. 0089	. 0013	. 0102
	80	. 0102	. 0015	. 0117
	90	. 0114	. 0017	. 0131
	100	. 0127	. 0019	. 0146
	110	. 0140	. 0021	. 0161
	120	. 0152	. 0023	. 0175
	130	. 0165	. 0025	. 0190
	140	. 0178	. 0026	. 0204
	150	. 0190	. 0029	. 0219

[1] For transport times at additional distances up to 150 feet, use the equation: $t=0.000146d$ when $d=$1-way distance in feet and $t=$productive time per round trip in man-hours.

TABLE 33.—*Labor required, per trip, for 1 man transporting produce to storage area and returning to carrier with empty equipment, when semilive skids and jacks were used*

Element description	Distance [1]	Base time	Allowances	Productive time
	Feet	*Man-hours*	*Man-hours*	*Man-hours*
Transport loaded and return empty: Begins when load clears bridge plate or original position on platform. Includes transporting loaded equipment to storage area and returning to carrier, with empty equipment. Ends when transporter contacts bridge plate or when transporter stops on platform.	10	0. 0036	0. 0007	0. 0043
	20	. 0048	. 0010	. 0058
	30	. 0062	. 0012	. 0074
	40	. 0075	. 0015	. 0090
	50	. 0088	. 0018	. 0106
	60	. 0101	. 0020	. 0121
	70	. 0114	. 0023	. 0137
	80	. 0127	. 0025	. 0152
	90	. 0140	. 0028	. 0168
	100	. 0153	. 0031	. 0184
	110	. 0166	. 0033	. 0199
	120	. 0179	. 0036	. 0215
	130	. 0192	. 0038	. 0230
	140	. 0205	. 0041	. 0246
	150	. 0218	. 0044	. 0262

[1] For transport times at additional distances up to 200 feet, use the equation: $t=0.000156d+0.0028$ when $d=$1-way distance in feet and $t=$productive time in man-hours per round trip.

TABLE 34.—*Labor required, per trip, for 1 man transporting produce to storage area and returning to carrier with empty equipment, when dead skids and manual low-lift platform trucks were used*

Element description	Distance [1]	Base time	Allowances	Productive time
	Feet	*Man-hours*	*Man-hours*	*Man-hours*
Transport loaded and return empty: Begins when load clears bridge plate or original position on platform. Includes transporting loaded equipment to storage area and returning to carrier, with empty equipment. Ends when truck contacts bridge plate or when transporter stops on platform.	10	0. 0048	0. 0010	0. 0058
	20	. 0063	. 0013	. 0076
	30	. 0077	. 0015	. 0092
	40	. 0092	. 0018	. 0110
	50	. 0106	. 0021	. 0127
	60	. 0121	. 0024	. 0145
	70	. 0136	. 0027	. 0163
	80	. 0150	. 0030	. 0180
	90	. 0165	. 0033	. 0198
	100	. 0179	. 0036	. 0215
	110	. 0194	. 0039	. 0233
	120	. 0208	. 0042	. 0250
	130	. 0222	. 0044	. 0266
	140	. 0237	. 0047	. 0284
	150	. 0252	. 0050	. 0302

[1] For transport times at additional distances up to 200 feet, use the equation: $t=0.000174d+0.0041$ when $d=$1-way distance in feet and $t=$productive time in man-hours per round trip.

TABLE 35.—*Labor required, per trip, for 1 man transporting produce to storage area and returning to carrier with empty equipment, when electric pallet transporters and pallets or electric low-lift platform trucks were used*

Element description	Distance [1]	Base time	Allowances	Productive time
	Feet	*Man-hours*	*Man-hours*	*Man-hours*
Transport loaded and return empty: Begins when load clears bridge plate or original position on platform. Includes transporting loaded equipment to storage area and returning to carrier, with empty equipment. Ends when transporter contacts bridge plate or when transporter stops on platform.	10	0. 0024	0. 0002	0. 0026
	20	. 0037	. 0004	. 0041
	30	. 0049	. 0005	. 0054
	40	. 0062	. 0006	. 0068
	50	. 0075	. 0008	. 0083
	60	. 0087	. 0009	. 0096
	70	. 0100	. 0010	. 0110
	80	. 0112	. 0011	. 0123
	90	. 0125	. 0012	. 0137
	100	. 0138	. 0014	. 0152
	110	. 0151	. 0015	. 0166
	120	. 0163	. 0016	. 0179
	130	. 0176	. 0018	. 0194
	140	. 0188	. 0019	. 0207
	150	. 0201	. 0020	. 0221

[1] For transport times at additional distances up to 300 feet, use the equation: $t=0.000151d+0.0014$ when $d=$1-way distance in feet and $t=$productive time in man-hours per round trip.

TABLE 36.—*Labor required, per trip, for 1 man transporting produce to storage area and returning to carrier, with empty equipment, when electric forklift trucks and pallets were used*

Element description	Distance [1]	Base time	Allowances	Productive time
	Feet	*Man-hours*	*Man-hours*	*Man-hours*
Transport loaded and return empty: Begins when load clears bridge plate or original position on platform. Includes transporting loaded equipment to storage area and returning to carrier, with empty equipment. Ends when forklift truck contacts bridge plate or when truck stops on platform.	10	0. 0063	0. 0006	0. 0069
	20	. 0071	. 0007	. 0078
	30	. 0079	. 0008	. 0087
	40	. 0087	. 0009	. 0096
	50	. 0096	. 0010	. 0106
	60	. 0104	. 0010	. 0114
	70	. 0112	. 0011	. 0123
	80	. 0120	. 0012	. 0132
	90	. 0128	. 0013	. 0141
	100	. 0137	. 0014	. 0151
	110	. 0145	. 0014	. 0159
	120	. 0153	. 0015	. 0168
	130	. 0162	. 0016	. 0178
	140	. 0170	. 0017	. 0187
	150	. 0178	. 0018	. 0196

[1] For transport times at additional distances up to 300 ft., use the equation: $t=0.000090d+0.0061$ when d=1-way distance in feet and t=productive time in man-hours per round trip.

TABLE 37.—*Labor required, per ton of produce, for 1 man performing miscellaneous receiving element*

Element description	Base labor	Allowances	Productive labor
	Man-hours	*Man-hours*	*Man-hours*
Remove ice: Begins when worker makes motion toward shovel, or grasps piece of ice. Includes walking to and picking up shovel, carrying shovel to ice, shoveling ice, returning shovel to resting position and walking to next package to be unloaded. Element ends when worker grasps package to be unloaded.			
Light	0. 0098	0. 0024	0. 0122
Medium	. 0285	. 0071	. 0356
Heavy	. 0779	. 0195	. 0974
Average	. 0355	. 0089	. 0444
Remove stripping: Begins when worker stops loading in order to remove stripping. Includes pulling stripping away from packages, removing, transporting, placing, and releasing stripping clear of work area and returning to work face to continue loading. Ends when worker grasps package.	. 0130	. 0020	. 0150

TABLE 38.—*Labor required,* per occurrence, *for performing miscellaneous receiving elements*

Element description	Workers in crew	Base labor	Allowances	Productive labor
Open car doors:				
1. Door on platform side: Begins when man grasps car seal on door latch. Includes breaking seal, grasping, turning and releasing locking mechanism, grasping, moving door or doors clear of threshold, and fastening doors in open position. Ends when man releases door or doors in open position	*Number* 1	*Man-hours* 0. 0142	*Man-hours* 0. 0021	*Man-hours* 0. 0163
2. Door on far side: Begins when man starts toward door on far side of car. Includes leaving platform, crossing rails, breaking seal, grasping, turning, and releasing locking mechanism, grasping, moving doors clear of threshold, fastening doors in open position, and returning to platform. Ends when man has returned to platform and is in position to perform next element	1	. 0270	. 0040	. 0310
Remove center bracing: Begins when man walks to a point near car threshold to pick up tool. Includes grasping, lifting, and transporting tool to car, performing all work necessary to break bracing loose, pulling bracing piecemeal from car, and placing on platform. Ends when last piece of bracing is released on platform	1	. 0881	. 0220	. 1101
Get bridge plate: Begins when worker starts to obtain bridge plate. Includes walking to pallet transporter, transporting to pickup point for bridge plate, grasping, lifting, placing, and releasing bridge plate on pallet transporter and transporting bridge plate to car or truck. Ends when pallet transporter stops near car threshold	1	. 0280	. 0028	. 0308
Position bridge plate: Begins when transporter stops near car threshold. Includes grasping, lifting, placing and releasing bridge plate in position to span gap between car or truck and platform. Ends when bridge plate is released	1	. 0140	. 0028	. 0168
	2	. 0188	. 0028	. 0216
Position bridge plate with pallet transporter: Begins when pallet transporter stops near car threshold. Includes pushing bridge plate off transporter, alining transporter so fork-tips extend over platform edge of bridge plate, pushing bridge plate across span between platform and car with transporter until car edge of bridge plate drops onto floor of car, and removing transporter. Ends when transporter clears bridge plate	1	. 0089	. 0009	. 0098
Remove bridge plate: Begins when worker grasps bridge plate. Includes lifting, transporting, and releasing bridge plate at storage point on platform. Ends when bridge plate is released	1	. 0040	. 0008	. 0048
	2	. 0060	. 0009	. 0069
Close car door: Begins when man grasps door. Includes unfastening door, grasping door or doors, moving to closed position and releasing, grasping, turning, fastening, and releasing locking mechanism. Ends when locking mechanism is released.				
1. Platform side	1	. 0059	. 0009	. 0068
2. Far side	1	. 0133	. 0020	. 0153

TABLE 39.—*Labor required, per ton of produce, for setup and cleanup, with specified crew organizations* [1]

Time item	1-man crew		2-man crew [2]		3-man crew [3]	
	Workers	Labor required	Workers	Labor required	Workers	Labor required
Productive labor:						
Set up:	*Number*	*Man-hours*	*Number*	*Man-hours*	*Number*	*Man-hours*
Open doors	1	0.0011	1	0.0011	1	0.0011
Get bridge plate	1	.0020	1	.0020	2	.0014
Position bridge plate	1	.0011	1	.0011	2	.0020
Clean up:						
Remove bridge plate	1	.0003	1	.0003	2	.0004
Close doors	1	.0004	1	.0004	1	.0004
Total productive labor		.0049		.0049		.0053
Unproductive labor:						
1 man waits while 2d man gets and positions bridge plate			1	.0020		
1 man waits while 2d man closes doors			1	.0001		
1 man waits while 2 men get and position bridge plate					1	.0006
2 men wait while 1 man closes doors					2	.0004
Total unproductive labor				.0021		.0010
Total labor required for setup and cleanup [4]	1	.0050	2	.0070	3	.0060
Elapsed hours		.0050		.0035		.0020

[1] Based on an average load of 15.15 tons per carrier.

[2] Crew organization: 1 man opens doors while 1 gets and positions bridge plate; 1 man removes bridge plate while 1 closes doors.

[3] Crew organization: 1 man opens doors while 2 get bridge plate; 2 men remove bridge plate while 1 closes doors.

[4] Rounded to three significant figures.

TABLE 40.—*Ownership and operation costs for 1 unit each of various types of materials-handling equipment. Cost per hour is based on 2,000 hours of use each year for receiving*

Equipment	Initial cost per unit	Expected useful life	Ownership costs				Operation costs			Total annual cost	Cost per hour
			Depreciation	Interest at 5 percent	Insurance and taxes at 4 percent	Total	Power	Maintenance	Total		
	Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Bridge plates (steel):											
For rail car	[1] 225.00	10	22.50	6.19	9.00	37.69		5.00	5.00	42.69	0.0213
For truck	[1] 106.00	10	10.60	2.92	4.24	17.76		5.00	5.00	22.76	.0114
2-wheel handtruck (1,000-pound capacity, rubber tired wheels)	[2] 20.00	12	1.67	.54	.80	3.01		2.00	2.00	5.01	.0025
2-wheel clamp truck (1,000-pound capacity)	[2] 45.00	12	3.75	1.22	1.80	6.77		6.00	6.00	12.77	.0064
Jack-lift for semilive skid (3,000-pound capacity)	[2] 35.00	12	2.92	.95	1.40	5.27		6.00	6.00	11.27	.0056
Semilive skid (2,000-pound capacity 36-by 54-inch)	[2] 17.50	12	1.46	.47	.70	2.63		5.00	5.00	7.63	.0038
Industrial forklift truck (2,000-pound capacity, 106-inch lift):											
Machine	[2] 2,450.00	8	306.25	68.91							
Battery (14.85 kilowatt-hour capacity)	[1] 1,250.00	5	250.00	37.50							
Charger	[2] 575.00	8	71.88	16.17							
Total	4,275.00		628.13	122.58	171.00	921.71	75.57	135.00	210.57	1,132.28	.5661
Industrial high-lift pallet transporter (2,000-pound capacity, 100-inch lift):											
Machine	[2] 1,500.00	8	187.50	42.19							
Battery (6.3 kilowatt-hour capacity)	[1] 670.00	5	134.00	20.10							
Charger	[2] 245.70	8	30.71	6.91							
Total	2,415.70		352.21	69.20	96.63	518.04	26.90	80.00	106.90	624.94	.3125
Industrial low-lift pallet transporter (4,000-pound capacity):											
Machine	[2] 825.00	8	103.12	23.20							
Battery (4.15 kilowatt-hour capacity)	[1] 405.00	5	81.00	12.15							
Charger	[2] 225.00	8	28.12	6.33							
Total	1,455.00		212.24	41.68	58.20	312.12	8.54	80.00	88.54	400.66	.2004

(Continued)

TABLE 40.—*Ownership and operation costs for 1 unit each of various types of materials-handling equipment. Cost per hour is based on 2,000 hours of use each year for receiving*—Continued

Equipment	Initial cost per unit	Expected useful life	Ownership costs				Operation costs			Total annual cost	Cost per hour
			Depreciation	Interest at 5 percent	Insurance and taxes at 4 percent	Total	Power	Maintenance	Total		
Industrial low-lift platform truck, electric (4,000-pound capacity):											
Machine	[2] 735.00	8	91.87	20.67							
Battery (4.15 kilowatt-hour capacity)	[1] 405.00	5	81.00	12.15							
Charger	[2] 225.00	8	28.12	6.33							
Total	1,365.00		200.99	39.15	54.60	294.74	8.54	80.00	88.54	383.28	.1916
Mechanical (4,000-pound capacity)	[2] 165.00	12	13.75	4.47	6.60	24.82		8.00	8.00	32.82	.0164
Hydraulic (4,000-pound capacity)	[2] 181.25	12	15.10	4.91	7.25	27.26		8.00	8.00	35.26	.0176
Pallet dollies:											
For rail car	[1] 159.00	10	15.90	4.37	6.36	26.63		5.00	5.00	31.63	.0158
For truck	[1] 51.00	10	5.10	1.40	2.04	8.54		5.00	5.00	13.54	.0067

[1] Entire cost charged to receiving.
[2] One-half of the initial cost charged to loading out operations.

TABLE 41.—*Ownership and operation costs of 1 unit each of pallets, dead skids, and semilive skids. Cost per use is based on 80 uses each year for receiving*

Equipment	Initial cost per unit[1]	Expected useful life	Ownership costs				Operation costs			Total annual cost	Cost per use
			Depreciation	Interest at 5 percent	Insurance and taxes at 4 percent	Total	Power	Maintenance	Total		
	Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Pallets (40- by 48-inch)	1.50	6	0.25	0.04	0.06	0.35		0.50	0.50	0.85	0.0106
Dead skids (36- by 54-inch)	6.00	13	.46	.16	.24	.86		.12	.12	.98	.0122
Semilive skids (36- by 54-inch)	17.50	20	.88	.46	.70	2.04		2.50	2.50	4.54	.0568

[1] One-half of total cost allocated to loading-out operations.

The figure used for the expected life of the equipment reflects the requirements of the tax policies of the Federal Government as well as depreciation suggestions of manufacturers.

An interest rate of 5 percent was assumed to cover either the cost of borrowing money to purchase equipment or the income lost when company assets were invested in equipment.

Insurance and local taxes on the equipment vary widely from one part of the country to another. Since recognition should be given to these items of ownership expense, 4 percent was assumed to be representative of nationwide requirements. An average power rate of $0.027 per kilowatt hour was obtained from statistics published by the Federal Power Commission. This represents a national average based on the commercial power rate schedule.

In table 40, it was assumed that each type of equipment would be used for 2,000 hours each year. This assumption permits a comparison of the equipment types on an equitable basis because the equipment would be fully utilized. In table 41, costs for pallets and skids have been computed on the basis of use. This basis was selected for allocating costs because, in the unit-load storage method, the pallet or skid is employed approximately once every 4½ days, or 80 times each year. The number of hours of use each year for a pallet or skid would be a small fraction of the 2,000 hours assumed for annual use of the equipment shown in table 40.

Labor Cost Data

To place cost comparisons on an equal basis, the same labor rates were used in each of the labor cost analyses associated with each equipment type used. The wage rate paid to the men employed by the wholesale distributor was assumed to be $2 per hour.[3] This rate includes the basic wages paid plus fringe benefits for social security, workers compensation insurance, paid vacations and unemployment compensation. The forklift truck operator's wage rate, assumed to be $2.25 per hour, also included base wages plus fringe benefits. This worker has the responsibility for running an expensive piece of equipment that requires more skill than other equipment.

Fatigue and Personal Allowances

The following allowances are applicable to the indicated handling operations performed in the warehouses of wholesale distributors of fresh fruits and vegetables. A personal allowance of 5 percent has been added to the fatigue allowance to provide the total allowance figure indicated.

[3] For an analysis of wage rates, see: Differentials in Workers' Earnings in Selected Segments of Food Marketing. U. S. Dept. Agr., AMS 333, Sept. 1959.

Time item	*Total fatigue and personal allowances*
All equipment types; each package handled by only 1 man:	
Load in carrier—	*Percent*
30-pound packages	15
40-pound packages	15
50-pound packages	20
80-pound packages	25
100-pound packages	25
Hand-stack—	
30-pound packages	20
40-pound packages	20
50-pound packages	25
80-pound packages	30
100-pound packages	30
2-wheel handtrucks and 2-wheel clamp trucks:	
Enter carrier	15
Pick up load	20
Exchange empty for loaded 2-wheel handtruck	20
Tip on load with 2-wheel handtruck	15
Leave carrier	15
Transport	15
Set down load	15
Exchange loaded for empty 2-wheel handtruck	15
Tip off load with 2-wheel handtruck	15
Release load for hand-stacking with 2-wheel clamp truck	10
Position stack of packages for 2-wheel clamp truck pickup	25
Pick up empty truck	10
Semilive skids and jacks, and dead skids and mechanical or hydraulic low-lift platform trucks:	
Manually position skid for loading, 1 man	25
Manually position skid for loading, 2 men	20
Position skid for loading with equipment	15
Enter carrier	15
Pick up load	20
Leave carrier	20
Transport	20
Position truck to set down load	25
Set down load	25
Position truck to pick up load	15
Pick up empty skids	15
Set down empty skids	15
Electric forklift truck, electric low-lift platform truck, and electric pallet transporter:	
All elements involving the operation of the equipment	10
Position skid or pallet for loading, 1 man	25
Position skid or pallet for loading, 2 men	20
Position pallet for loading with pallet dolly, 1 man	15
Position pallet for loading with pallet dolly, 2 men	10
Position loaded pallet for pickup, 1 man	20
Position loaded pallet for pickup, 2 men	15
Miscellaneous:	
Remove ice	25
Remove stripping	15
Open or close car doors	15
Remove center bracing	25
Get bridge plate with pallet transporter	10
Position or remove bridge plate, 1 man	20
Position or remove bridge plate, 2 men	15
Position bridge plate with pallet transporter	10

Storage Area Requirements

Each storage method and equipment type used has a direct effect on the number of square feet of storage area required. The storage area must include not only the floor space for holding fruits and vegetables but also space for a service aisle. The equipment type determines the aisle width.

TABLE 42.—*Package data for a representative inventory of fruits and vegetables*

Commodity storage area	Container size			Package weight	Packages stored	Pounds stored
	Length	Width	Height			
General:	*Inches*	*Inches*	*Inches*	*Pounds*	*Packages*	*Pounds*
Cantaloup	24	13	13	85	99	8, 415
Lemons	17½	11½	11	40	180	7, 200
Onions	28	15	9	50	270	13, 500
Potatoes	32	16	9	100	1, 656	165, 600
Sweetpotatoes	[1] 19D	14D	13	55	120	6, 600
Tomatoes	17½	14	6	32	290	9, 280
Watermelons				33	384	12, 672
Other [2]				40	424	16, 960
Subtotal					3, 423	240, 227
Dry cold:						
Apples	19½	12½	11	50	624	31, 200
Grapefruit	17½	11¾	11	40	540	21, 600
Grapes	17½	14	7	32	264	8, 448
Lettuce	22	14	12	42	1, 318	55, 356
Oranges	17½	12	10½	40	650	26, 000
Peaches	[1] 21D	14D	15	55	84	4, 620
Other [3]				49	321	15, 729
Subtotal					3, 801	162, 953
Wet cold:						
Cabbage	33	14	10	50	440	22, 000
Carrots	19	13½	9½	50	357	17, 850
Celery	22	16½	10½	60	336	20, 160
Corn	24	11	10	50	145	7, 250
Other [4]				50	321	16, 050
Subtotal					1, 599	83, 310
Grand total					8, 823	486, 490

[1] "D" indicates diameter of bushel basket.

[2] Average data for green beans, cucumbers, eggplant, melons, okra, and sweet pepper.

[3] Average data for cranberries, pears, and summer squash.

[4] Average data for artichokes, asparagus, lima beans, beets, broccoli, brussels sprouts, cauliflower, green peas, radishes, spinach, turnips, endive, and escarole.

To make equitable comparisons of storage areas required, a number of assumptions were made. All the storage methods and equipment types that were analyzed were affected by these assumptions:

1. Space required was proportional to the annual volume of each commodity handled.

2. The inventory turnover rate was once every 4½ days or 80 times per year.

3. A representative inventory for 4½ days' business in proportion to the annual volumes would be divided between storage areas as shown in table 42. This provides a storage volume of approximately 7 carload equivalents in general storage, 5 in dry cold storage, and 3 in wet cold storage. These volumes would be comparable to the supplies needed to maintain a representative inventory for a wholesale business handling an annual volume of approximately 1,000 carload equivalents.

4. A unit storage bay approximately 10 by 14 feet was used to determine the number of tons stored therein for each method and equipment type.

5. To determine the number of square feet of storage area required per ton, the total tons stored in the unit storage bay were divided into the bay area plus an area equal to half the aisle width times its length. Aisle length was equal to the bay width. Each type of equipment and its related storage method were analyzed, and a specific number of square feet of warehouse space per ton stored was determined. These figures provided a basis for comparison.

Storage bay areas varied in size from 140 to 148.6 square feet. Small adjustments were made in bay dimensions for pallets and skids because of slightly different area requirements to accommodate a number of skids or pallets.

Several steps were required to determine the number of square feet needed for each ton stored. In table 43 a representative inventory (for a period of 4½ days) was stored on pallets. Three hundred and twenty-two 48- by 40-inch pallet loads were required. However, 25 percent of these were stored on top of other pallet loads; therefore actual floor space had to be provided for only 242

TABLE 43.—*Number of 48- by 40-inch pallet loads required to store a representative inventory of fruits and vegetables*

Commodity storage area	Packages per pallet	Weight per pallet	Pallets required	Pallet spaces required
General:	*Packages*	*Pounds*	*Pallets*	*Spaces*
Cantaloup	20	1,700	5	2½
Lemons	40	1,600	5	2½
Onions	40	2,000	7	7
Potatoes	20	2,000	83	83
Sweetpotatoes	20	1,100	6	6
Tomatoes	48	1,536	6	3
Watermelons			11	5½
Other [1]			14	14
Subtotal			137	123½
Dry cold:				
Apples	35	1,750	18	9
Grapefruit	40	1,600	14	7
Grapes	48	1,536	6	3
Lettuce	30	1,260	44	22
Oranges	40	1,600	16	8
Peaches	20	1,100	4	4
Other [2]			10	10
Subtotal			112	63
Wet cold:				
Cabbage	20	1,000	22	22
Carrots	35	1,750	10	5
Celery	18	1,080	19	9½
Corn	24	1,200	6	3
Other [3]			16	16
Subtotal			73	55½
Grand total			322	242

[1] See footnote 2, table 42.
[2] See footnote 3, table 42.
[3] See footnote 4, table 42.

pallets. Two hundred and eighty-nine 36- by 54-inch semilive skids or dead skids were required for a representative inventory (table 44). Since this equipment cannot be tiered, 289 floor spaces were required.

Calculations for the unit storage bay and for the aisle are shown in table 45. The first column of this table covers both semilive and dead skids. The average weight per skid was 0.84 ton. Each skid space was 41 by 58 inches. These dimensions include an allowance for overlap of 3 inches on the skid width, plus 2 inches for clearance between skids, and a 4-inch allowance for overlap on the skid length. Each storage space required 16.51 square feet. A unit storage bay area of 148.6 square feet can accommodate 9 skids and a total of 7.5 tons stored. Adding aisle area to the unit storage bay area, and dividing the total by the tons stored, showed 27 square feet per ton required for fruits and vegetables stored intact on semilive or dead skids.

TABLE 44.—*Number of 36- by 54-inch semilive and dead skids required to store a representative inventory of fruits and vegetables*

Commodity storage area	Packages per skid	Weight per skid	Skids required
General:	*Packages*	*Pounds*	*Skids*
Cantaloup	24	2,040	4
Lemons	48	1,920	4
Onions	30	1,500	9
Potatoes	20	2,000	83
Sweetpotatoes	20	1,100	6
Tomatoes	64	2,048	5
Watermelons	39	1,287	10
Other [1]	26.1	1,044	16
Subtotal			137
Dry cold:			
Apples	40	2,000	16
Grapefruit	48	1,920	11
Grapes	64	2,048	4
Lettuce	36	1,512	37
Oranges	48	1,920	14
Peaches	20	1,100	4
Other [2]	35.2	1,725	9
Subtotal			95
Wet cold:			
Cabbage	20	1,000	22
Carrots	40	2,000	9
Celery	28	1,680	12
Corn	30	1,500	5
Other [3]	35.5	1,775	9
Subtotal			57
Grand total			289

[1] See footnote 2, table 42.
[2] See footnote 3, table 42.
[3] See footnote 4, table 42.

The same kind of analysis was made when pallets and pallet transporters were used. The unit-load principle of storage was used, but it was assumed in the figures shown in the second column of table 45 that pallets were not tiered. As a result, a total of 29 square feet were required for each ton stored.

In the third column, data on pallets were based on the assumption that partial pallet tiering was used. As a result, 12 pallets, or 9.1 tons, were stored in the floor space required for 9 pallets. Placing 1 out of every 4 pallets on top of 1 already stored on the floor cuts the floor space required from 29 to 23 square feet per ton.

When 2-wheel stevedore or clamp type handtrucks were used with the unit-load method for storage, approximately 3,809 square feet of commodity storage space were required (table 46) for the representative inventory of 243 tons. Area requirements by commodity were based on package dimensions plus an allowance of 2 inches for load clearance and air circulation. Total area per commodity would depend upon: the proportionate

TABLE 45.—*Space required when commodities are stored on pallets or skids*

Storage space item	Unit	Storage methods		
		On semilive or dead skids 36- by 54-inch	On pallets 48- by 40-inch, no tiering	On pallets 48- by 40-inch, partial tiering
(1) Weight per pallet or skid	Tons	0. 84	0. 76	0. 76
(2) Area per pallet or skid space	Square feet	16. 51	16. 25	16. 25
(3) Pallets or skids in storage bay	Number	9	9	12
(4) Pallets or skid spaces in storage bay	do	9	9	9
(5) Area per storage bay (2) x (4)	Square feet	148. 6	146. 2	146. 2
(6) Weight per storage bay (1) x (3)	Tons	7. 5	6. 8	9. 1
(7) Aisle area required	Square feet	[1] 50. 4	[2] 48. 8	[3] 61. 9
(8) Total area for aisle and storage bay (5) + (7)	do	199. 0	195. 0	208. 1
(9) Average area per ton (8) ÷ (6)	do	27	29	23

[1] One-half of aisle 9 feet, 10 inches wide, 10 feet, 3 inches long.
[2] One-half of aisle 8 feet, 8 inches wide, 11 feet, 3 inches long (for low-lift pallet transporter).
[3] One-half of aisle 11 feet wide, 11 feet, 3 inches long (for high-lift pallet transporter and forklift truck).

TABLE 46.—*Handtruck loads required to store a representative inventory of fruits and vegetables*

Commodity storage area	Handtruck loads				
	Packages per load	Weight per load	Loads required	Area per load	Total area required
General:	*Packages*	*Pounds*	*Loads*	*Square feet*	*Square feet*
Cantaloup	5	425	20	2. 4	48. 0
Lemons	6	240	30	1. 6	48. 0
Onions	6	300	45	3. 1	139. 5
Potatoes	5	500	331	3. 8	1, 257. 8
Sweetpotatoes	6	330	20	2. 8	56. 0
Tomatoes	8	256	36	1. 9	68. 4
Watermelons	8	264	48	2. 9	139. 2
Other [1]	7. 4	296	56. 4	2. 4	135. 4
Subtotal					1, 892. 3
Dry cold:					
Apples	6	300	104	1. 9	197 6
Grapefruit	6	240	90	1. 6	144. 0
Grapes	8	256	33	1. 9	62. 7
Lettuce	6	252	220	2. 3	506. 0
Oranges	6	240	108	1. 6	172. 8
Peaches	6	330	14	3. 4	47. 6
Other [2]	6. 1	299	52. 6	1. 9	99. 9
Subtotal					1, 230. 6
Wet cold:					
Cabbage	6	300	73	3. 4	248. 2
Carrots	6	300	60	2. 0	120. 0
Celery	6	360	56	2. 8	156. 8
Corn	6	300	24	2. 0	48. 0
Other [3]	6. 8	340	47. 2	2. 4	113. 3
Subtotal					686. 3
Grand total					3, 809. 2

[1] See footnote 2, table 42.
[2] See footnote 3, table 42.
[3] See footnote 4, table 42.

number of packages of that commodity to be stored, divided by the packages per load, times the package area, plus required clearance area. (Package dimensions for principal commodities are given in table 42.)

Hand-stacking on the warehouse floor required interlocking patterns for bagged items. Other items were stored in blocks, 2 packages across, with the long dimension parallel to the aisle. A 2-inch space was allowed between blocks for air circulation and for ease in removal. The height of the block varied with the commodity and its container's dimensions. The maximum height was 96 inches.

The number of packages in a block was based on the maximum combination of packages that would result in effective use of space. To determine the number of blocks required, the number of packages of each commodity in a block was divided into the total number of packages of that commodity in the representative inventory.

Using this stacking procedure, approximately 2,817 square feet were required to store the 243 tons of the representative inventory (table 47).

Nineteen square feet of storage and aisle space were required for each ton received when handtrucks were used to tip off or release unit loads intact in storage (table 48). When packages were hand-stacked, 14 square feet per ton were required. The area was less for manual-stacking on the floor because packages could be stacked higher with this method than with the unit-load method.

When semilive skids were used to move produce to the storage area for hand-stacking, 16 square feet per ton were required. The wider aisle required for semilive skids increased the area requirement over that for two-wheel handtrucks. The same unit storage bay was used.

TABLE 47.—*Floor area required when a representative inventory of fruits and vegetables is hand-stacked in storage*

Commodity storage area	Hand-stacking				
	Packages per block	Weight per block	Blocks required	Area per block	Total area required
General:	*Packages*	*Pounds*	*Blocks*	*Square feet*	*Square feet*
Cantaloup	64	5, 440	2	18. 1	36. 2
Lemons	54	2, 160	3	9. 4	28. 2
Onions	14	700	19	6. 7	127. 3
Potatoes	14	1, 400	118	7. 6	896. 8
Sweetpotatoes	20	1, 100	6	10. 6	63. 6
Tomatoes	68	2. 176	4	7. 2	28. 8
Watermelons	40	1, 320	10	14. 0	140. 0
Other [1]	28. 0	1, 120	15	7. 2	108. 0
Subtotal					1, 428. 9
Dry cold:					
Apples	54	2, 700	12	10. 5	126. 0
Grapefruit	54	2, 160	10	9. 1	91. 0
Grapes	56	1, 792	5	7. 2	36. 0
Lettuce	54	2, 268	24	13. 4	321. 6
Oranges	60	2, 400	11	9. 2	101. 2
Peaches	16	880	5	12. 8	64. 0
Other [2]	46. 2	2, 264	7	8. 1	56. 7
Subtotal					796. 5
Wet cold:					
Cabbage	12	600	37	8. 0	296. 0
Carrots	66	3, 300	6	11. 2	67. 2
Celery	30	1, 800	11	10. 1	111. 1
Corn	60	3, 000	3	11. 5	34. 5
Other [3]	52. 4	2, 620	6	13. 8	82. 8
Subtotal					591. 6
Grand total					2, 817. 0

[1] See footnote 2, table 42.
[2] See footnote 3, table 42.
[3] See footnote 4, table 42.

TABLE 48.—*Space required when commodities are hand-stacked or tipped off in storage*

Storage space item	Units	Storage methods		
		Tip off or release in storage	Hand-stack from 2-wheel equipment	Hand-stack from semilive skids
(1) Weight stored	Tons	243	243	243
(2) Total area required	Square feet	3, 809	2, 817	2, 817
(3) Weight per square foot (1) ÷ (2)	Tons	. 064	. 086	. 086
(4) Area per storage bay [1]	Square feet	140. 0	140. 0	140. 0
(5) Weight per storage bay (3) × (4)	Tons	9. 0	12. 0	12. 0
(6) Aisle area required	Square feet	[2] 31. 7	[2] 31. 7	[3] 49. 2
(7) Total area for aisle and storage bay (4) + (6)	do	171. 7	171. 7	189. 2
(8) Average area per ton (7) ÷ (5)	do	19	14	16

[1] Storage bay is 14 by 10 feet.
[2] One-half of aisle 6 feet, 4 inches wide, 10 feet long.
[3] One-half of aisle 9 feet, 10 inches wide, 10 feet long.

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